SUMMARY REPORT OF DoD FUNDED LIGHTER-THAN-AIR-VEHICLES

LIGHTER-THAN-AIR VEHICLES

This report provides a comprehensive overview of all current and planned programs funded within the Department of Defense (DoD) to include aerostats, airships, and rigid-aeroshell variable buoyancy vehicles.

Prepared by the Office of the Assistant Secretary of Defense for Research and Engineering, Rapid Reaction Technology Office

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EXECUTIVE SUMMARY

In the Senate report accompanying S.1253 (S. Rept. 112-26) of the National Defense Authorization Act (NDAA) for Fiscal Year 2012, Congress tasked the Department of Defense (DoD) to provide the congressional defense committees a report that "reviews the status and future plans [for DoD funded aerostats, airships, and rigid aeroshell variable buoyancy vehicle programs] to ensure that the most cost-effective systems are being pursued and that the highest priority science and technology challenges for persistent unmanned capabilities are being addressed." This document fulfills that tasking. Specifically, individual profiles for each DoD funded program are given on pages 13–36 and 40–60. The profiles detail the program origin, current status, operational characteristics, and future plans for each of the DoD funded aerostat, airship, and rigid aeroshell variable buoyancy vehicles. Where applicable, the collaboration among stakeholder organizations is noted in the program overview tables. The profiles also highlight technical objectives and science and technology challenges that are being addressed as part of the programs. Many of these challenges are being assessed through development of demonstrator-scale and hangar-model systems to establish a baseline prior to full scale system development. Moreover, small initial procurements and test platforms are being used in some cases to assess system and subsystem performance prior to higher volume acquisitions.[1]

After comprehensive review of the DoD funded aerostat and airship programs, the investments made within DoD (including Service specific efforts) are addressing key technology areas that will enable viable lighter-than-air vehicles to contribute to our short, mid, and long term strategy for national security and defense. These technical challenges include:

- Developing smaller aerostat systems with enhanced lift capabilities to provide small, mobile, tactical units with organic surveillance capabilities
- Improving aerostat platform survivability through the development of better flight guidelines, weather forecasting architecture, and software to provide automatic alerts for protection against environmental stress factors such as lightning and wind microbursts
- Increasing mission duration of airships through advanced hull designs, internal structures and materials
- Enabling vertical take-off and landing capabilities with minimal ground handling crews through development of a variable buoyancy control system and advanced forward/aft motion controls
- Developing advanced intelligence, surveillance, reconnaissance and communications capabilities through integrated sensor payloads and on-board processing for real-time intelligence and post-mission forensics

Moreover, advances and investment in aerostat and airship technology are also being made in the private sector. The DoD is monitoring this progress and will continue to look for opportunities to advance our objectives through commercially available technology.

The data and information provided in this report is accurate as of June 2012.

Lighter-Than-Air Vehicle Classifications

LTA vehicles fall into two categories: powered and unpowered air vehicles. Powered vehicles can be further separated into conventional and hybrid categories, distinguished by the mechanism by which the vehicle obtains lift. Conventional airships generate virtually all of their lift by the static buoyancy of a contained lifting gas, usually helium. Hybrid airships combine static lift (buoyant) and dynamic lift generated by aerodynamic effects induced by some combination of vertical and horizontal thrusters or hull shape. Unpowered vehicles are either tethered aerostats or un-tethered balloons that generate all of their lift by the static buoyancy of a lifting gas and remain at the launch location in the case of aerostat or float on atmospheric winds in the case of balloons.[2]

Currently within the DoD, LTA vehicles are primarily utilized for ISR missions, but developmental hybrid airships are being researched for logistic airlift missions as well. Modern aerostats have been actively deployed in numerous military operations since the 1980s. In OIF and OEF, aerostats are used as ISR, COMMS, and force protection assets. Aerostats are floated at forward operating bases (FOBs) to inhibit, detect, and monitor insurgent activities day and night. Modern airships remain largely developmental. Demonstrator size vehicles are being developed to establish technological viability and system proofs of concept. Military interest in airships revolves around logistical airlift and low- or high-altitude ISR capabilities. For airlift missions, airships could provide transport of equipment and personnel at higher speeds than current sea or land options and without the need for runways or travel routes. For ISR missions, airships could provide persistent (months to years) ISR and COMMS capabilities at low and high altitudes.

Aerostats and airships are currently utilized or developed by all services of the military as well as other organizations and agencies under the Office of the Secretary of Defense (OSD). The summary below provides an overview of the currently funded (or recently concluded) LTA programs within the DoD.

Aerostats

Aerostat Test Bed (ATB) — ATB are Army owned aerostats that serve as high-altitude surrogate platforms in support of payload development and testing (e.g., sensors and communications). The ATB aerostats are manufactured by both Raven and Lindstrand. There are no other DoD agencies collaborating with the Army on the ATB program. These platforms provide test bed services for payload development and testing; thus, no scientific or technical challenges regarding LTA technology are being addressed as part of this program. Currently, the systems reside at Colorado Springs testing grounds and are scheduled to participate in the U.S. Army’s Network Integration Evaluation (NIE) 13.1 exercise.

Altus — Altus is an Army owned aerostat that enhances a small units persistent surveillance capabilities. Altus is manufactured by Silicis Technology Inc. There are no other DoD agencies collaborating with the Army on the Altus program. The technical challenges of this program are the development of a highly automated platform capable of unmanned airship and aerostat operation in a compact, portable, and easy to use design. Currently, the Army G-2 is testing the system for comparison against Rapidly Elevated Aerostat Platform XL B (REAP XL B).

Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) — JLENS is an Army owned aerostat that provides persistent surveillance and tracking capabilities

for unmanned aerial vehicle and cruise missile defense to the current and projected defense forces. JLENS aerostats are manufactured by Tethered Communications, Inc. (TCOM). The Army is the lead Service for the JLENS program via the Aerostat Joint Project Office. There is interest in this program by the other Services for applications to Joint Integrated Air and Missile Defense. The technical challenge being addressed by JLENS is establishing a highly responsive radar detection network capable of providing fire control quality data to fighter aircraft and surface-to-air missiles systems. The data will allow engagement of hostile threats below, outside or beyond these systems' fields of view and from extended ranges. Currently, the system is under developmental testing.

Persistent Ground Surveillance System (PGSS) — PGSS is a Navy owned aerostat that provides continuous, real-time ISR, force protection, FOB protection, and oversee support to FOBs throughout OEF. PGSS is manufactured by Raven and TCOM. It is deployed at multiple FOBs in OEF. The PGSS program is a Navy led effort in collaboration with the Army. The technical challenge being addressed by the program is providing advanced real-time ISR capabilities to observe attack preparation, IED emplacements and insurgent activities. Currently, 59 systems have been ordered. PGSS will be rolled up under a new Persistent Surveillance Systems-Tethered (PSS-T) Program of Record (POR), and will be managed by Program Manager (PM) Meteorological and Target Identification Capabilities (MaTIC) by 2014.

Persistent Threat Detection System (PTDS) — PTDS is an Army owned aerostat that provides long-endurance and real-time ISR, force protection, FOB protection, and route and C-IED support. PTDS is manufactured by Lockheed Martin. It was first deployed in OIF in 2004 and since at multiple FOBs in OIF and OEF. The PTDS is an Army program and does not have collaboration from the other DoD agencies. The primary technical challenge being addressed is platform survivability due to environmental stress factors such as lightning and wind microbursts. The PTDS platform is also the only aerostat capable of carrying a 1,000 lb. payload to an altitude of 8,000 ft. mean sea level (MSL). Currently, PTDS is operating in OEF. Future plans for the system are to continue support in theater and for PTDS to be rolled up under PSS-T POR and managed by PM MaTIC by 2014.

Rapid Aerostat Initial Deployment (RAID) — RAID is an Army owned aerostat that provides persistent, panoramic surveillance of the covered area, providing timely warning of potential threats and other events valued for intelligence purposes. RAID aerostats are manufactured by TCOM. The RAID program was initiated by the Joint Improvised Explosive Device Defeat Organization (JIEDDO) in 2003 to support the Defeat the Device mission. The Army is the lead Service for the program. Previously, these systems were deployed in OIF and OEF; however, no systems are currently active. There are 19 systems in sustainment in the Kuwait reset facility awaiting direction from U.S. Central Command (USCENTCOM). The program is currently in the sustainment phase; thus, no technical advancements or challenges are currently being addressed.

Rapidly Elevated Aerostat Platform XL B (REAP XL B) — REAP is an Army owned aerostat that provides a small, compact, highly mobile, rapidly deployable/recoverable ISR system. REAP is manufactured by Information Systems Laboratories Incorporated (ISL). Several REAP systems are deployed in OEF with combatant commander and other tactical units to provide ISR, force protection, and detecting/identifying targets in day, night, and limited visibility. This program is a joint effort between the Army and the Navy. Similar to the Altus program, the REAP XL B program is developing a compact, portable, and easy to use aerostat

design for rapid deployment of ISR and force protection capabilities. Currently, two REAP XL B systems have been procured by the Army and are deployed to OEF to characterize their performance as alternatives to the PGSS and PTDS systems.

Small, Tactical, Multi-Payload Aerostat System (STMPAS) — STMPAS is an Army owned aerostat that provides an affordable, small-scale, mobile aerostat platform for ISR and force protection support to small operational forces. STMPAS is manufactured by Carolina Unmanned Vehicles, Inc. There are no other DoD agencies collaborating with the Army on the STMPAS program. The technical focus of this program is the development of a compact, portable, easy to use, and highly durable aerostat platform that is capable of operating during adverse weather conditions. Currently, the Army G-2 is testing the system for comparison against REAP XL B.

Tethered Aerostat Radar System (TARS) — TARS is a DoD owned aerostat that provides a long-range detection and monitoring capability for low-altitude narcotics traffickers approaching the United States. The TARS system is manufactured by Lockheed Martin. These systems are deployed along the U.S. southern border and in Puerto Rico. The Air Force is the Executive Agent for the TARS program, which is supporting missions for U.S. Northern Command (USNORTHCOM), U.S. Southern Command (USSOUTHCOM), and North American Aerospace Defense Command (NORAD). The program is currently in the sustainment phase; thus, no technical advancements or challenges are being addressed. Current plans are to transition TARS to the Department of Homeland Security (DHS).

Airships

Blue Devil 2 — The Blue Devil 2 program is an Air Force Quick Reaction Capability (QRC) development effort whose goal is to provide a low-altitude airship platform for Command, Control, Communications, Computers ISR (C4ISR) fusion. The contractor is Mav6. This is an Air Force led program, with collaboration from the Army and JIEDDO. The technical focus of the program is to provide an airship-based ISR aerial fusion node that integrates multiple distributed and local sensors with on-board processing for real-time intelligence and post-mission forensics. Due to recent technical failures, the Air Force has halted the program.

High-Altitude, Long Endurance-Demonstrator (HALE-D) — HALE-D is a sub-scale technology demonstrator developed by the U.S. Army Space and Missile Defense Command (SMDC) in conjunction with prime contractor Lockheed Martin. SMDC flight-tested the airship in the summer of 2011, but it failed to reach the upper altitude objective of 60,000 ft. This program is a joint effort by the Army and Missile Defense Agency (MDA). The technical focus of the program is to demonstrate an airship that is capable of carrying a payload, e.g., ISR and COMMS, of 2,000 lbs. or more to an altitude above 65,000 ft. MSL for at least 30 days. The project is currently unfunded.

HiSentinel — As part of the HiSentinel program, the U.S. Army SMDC developed a series of increasingly larger volume high-altitude airships with contractors Southwest Research Institute (SwRI) and Aerostar International. The most recent version is nearly 200 ft. in length and can carry a payload of up to 80 lbs. The HiSentinel aircraft are unique in that they are launched flaccidly and obtain their final form once they reach altitude. There are no other DoD agencies collaborating with the Army on the HiSentinel program. The goal of the program is to create a low-cost, expendable airship that can provide a long-duration tactical platform for military and homeland security applications, such as communications relay and border protection. SMDC stopped the program after a failed flight test in 2010.

Integrated Sensor Is Structure (ISIS) — ISIS is a joint Defense Advanced Research Projects Agency (DARPA) and Air Force Science and Technology (S&T) program that integrates advanced radar with tracking and moving target indication directly into the structure of a high-altitude airship. The program began in 2004 as a joint DARPA and Air Force program with contractors Lockheed Martin and Raytheon. The technical focus of the program is to create a persistent, wide area surveillance (WAS), tracking and engagement capability for hundreds of time-critical air and ground targets. Currently, the airship is in its third phase of development of a half-scale demonstrator, which has a planned flight scheduled for FY14.

Long Endurance Multi-Intelligence Vehicle (LEMV) — The LEMV airship is a hybrid airship designed to provide low-altitude ISR capabilities. The LEMV is being developed by the U.S. Army SMDC and prime contractor Northrup Grumman. The United Kingdom's Hybrid Air Vehicles, Inc. designed the LEMV envelope. The first flight for operational testing is scheduled to occur in the summer of 2012. There are no other DoD agencies collaborating with the Army on the LEMV program. The objective of the program is to provide a long-endurance capability (up to 21 days) for persistent ISR missions. SMDC has studied variations of the low-altitude ISR version to adapt the LEMV for heavy- airlift logistics operations as well.

MZ-3A — MZ-3A is the only currently operational airship owned by the DoD. The MZ-3A is a repurposed American Blimp Corporation A-170 that is primarily used as a flying laboratory for testing sensor payloads. The MZ-3A is owned by the Navy and contractor operated by Integrated System Solutions, Inc. The Army plans to use it for payload testing in the next fiscal year. This platform provides test bed services for payload development and testing.

Pelican — The Pelican is a Rigid Aeroshell, Variable Buoyancy (RAVB) hybrid airship. The development effort is led by the Office of the Assistant Secretary of Defense (Research and Engineering) (ASD[R&E])–Rapid Reaction Technology Office (RRTO) and National Aeronautics and Space Administration (NASA) Ames Research Center with contractor Aeros Corporation providing the aircraft. The technical objectives of the Pelican program are to integrate and demonstrate several key technologies that could enable LTA airlift capabilities. These include a buoyancy control system enabling ballast independent operations; a rigid, lightweight-composite internal structure; a responsive low-speed/hover control system; and ground handling capabilities to enable operations without a ground handling crew. Aeros is preparing for a hangar demonstration to take place by the end of 2012.

Skybus — Skybus is an experimental, remotely piloted, unmanned airship owned by the Army, which is used primarily as a payload test platform. The current version is an 80,000 cu. ft. airship developed by SAIC. This platform provides test bed services for payload development and testing; thus, no scientific or technical challenges regarding LTA technology are being addressed as part of this program. The Skybus uses a multi-payload gondola equipped with Full Motion Video (FMV) turrets, Star Safire III, communications relays, and wideband networks equipment. This equipment is used to facilitate testing a variety of ISR and communications payloads developed by a number of organizations, including industry and government labs, e.g., Air Force Research Lab (AFRL), Army Research Lab (ARL), and the Naval Research Lab (NRL). The Army is reassembling it for an operational demonstration to occur by the end of fiscal year (FY) 2012.

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Preface

Congress, through the Senate report accompanying S. 1253 (S. Rept. 112-26) of the National Defense Authorization Act of Fiscal Year 2012, directed the Department of Defense to provide the congressional defense committees with a report that reviews the status and future plans for DoD funded aerostats, airships, and rigid aeroshell variable buoyancy vehicle programs to ensure that the most cost-effective systems are being pursued and that the highest priority science and technology challenges for persistent unmanned capabilities are being addressed.[1] The Office of the Assistant Secretary of Defense for Research and Engineering prepared this report to satisfy the congressional mandate.

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PURPOSE

The purpose of this document is to serve as a summary report on the current status and future plans for all DoD-funded air vehicle programs. With numerous air vehicle programs currently in development across the DoD, a consolidated knowledge will enable better oversight, more effective use of DoD resources, and cross-pollination of technologies across programs and services. The purpose of this report is twofold: (i) to inform the senior official with oversight authorities for airship-related programs, and (ii) to satisfy the Senate report mandate. This report covers all currently funded (or recently concluded) DoD aerostats, airships, and RAVB vehicles. Balloons with ISR or logistic capabilities are also briefly covered in Appendix A. Table 1 provides an overview of the currently funded (or recently concluded) LTA programs within the DoD.

Methodology

An exhaustive review was completed on open source resources to identify points of contact for known DoD programs that have funded aerostats, airships, RAVB vehicles and balloons with ISR or logistic capabilities. Points of contact across the air vehicle development community and program representatives were interviewed to collect the required data sets and identify any additional programs that fall within the report’s scope. The data was analyzed, organized and used to develop this report.

This report provides a brief history of LTA vehicle technology and defines a categorization schema of the various air vehicle types. The programs are divided into two groups—aerostats and airships—with an overview of each classification. Detailed profiles broken down by technical detail, history, and programmatics for the various DoD aerostats and airships are also included.

Table 1: Summary of DoD LTA Vehicles		
Aerostats	**Agency**	**Status**
Aerostat Test Bed (ATB)	Army	Test & Evaluation
Altus	Army	Test & Evaluation
Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS)	Army	Test & Evaluation
Persistent Ground Surveillance System (PGSS)	Navy	Deployed OEF
Persistent Threat Detection System (PTDS)	Army	Deployed OEF
Rapid Aerostat Initial Deployment (RAID)	Army	In Storage
Rapidly Elevated Aerostat Platforms XL B (REAP XL B)	Army	Deployed OEF
Small, Tactical, Multi-Payload Aerostat System (STMPAS)	Army	Test & Evaluation
Tethered Aerostat Radar System (TARS)	Air Force	Deployed U.S. Borders
Airships		
Blue Devil 2	Air Force	Currently Unfunded
High-Altitude Long Endurance Demonstrator (HALE-D)	Army	Currently Unfunded
HiSentinel	Army	Currently Unfunded
Integrated Sensor Is Structure (ISIS)	DARPA, Air Force	Development
Long Endurance Multi-Intelligence Vehicle (LEMV)	Army	Test & Evaluation
MZ-3A	Navy	Active T&E Platform
Pelican	ASD(R&E), NASA Ames	Development
Skybus	Army	In Storage

INTRODUCTION

Background

Modern LTA craft have a lineage spanning back to the flight of the first hot air balloon by Joseph and Étienne Montgolfier of France in 1783. Since that time, LTA vehicles have seen a variety of military and commercial uses. For example, balloons were used to raise scouts several hundred feet into the air to observe troop movements during the American Civil War. In the late 19th century, Count Ferdinand von Zeppelin developed the first rigid shell airship, the LZ-1, which weighed 13 tons and saw use first for passenger travel and later in the German military. LZ-1s were used in the Zeppelin bombing campaigns of World War I and also as defense assets, surveying harbors and protecting convoys.[3] “Airships were attractive during the early days of military aviation because, with buoyancy provided by hydrogen or helium, the engines needed only enough power to move the aircraft at relatively low speed and airframes needed only enough strength to support their own weight and to withstand the relatively mild stresses associated with low-speed flight. Fixed-wing aircraft, in contrast, required stronger airframe structures and more powerful and reliable engines because their lift is derived from pushing wings through the air at high speed.”[4] Military interest in LTA vehicles stems from their ability to support persistence, loitering, weapons delivery and, more recently, potential logistics mission capabilities.

The historical role of LTA vehicles in military engagement varied depending on the technological advancements at the time and the ability of adversaries to mount defenses against the vehicles. The U.S. military has procured, tested, developed and used LTA vehicles since the 1920s. The initial airships, all clad or rigid envelope structures, were used largely for experimental, transport and utility purposes. After several airships were lost, construction transitioned to non-rigid airships. Immediately prior to and during World War II, airship production increased and the vehicles played an important role in efforts such as sweeping for mines, performing search and rescue, escorting convoys and various ISR tasks such as scouting, photographic reconnaissance, and antisubmarine patrols.[5] While airships saw some use in bombing campaigns, too many systems were lost to fighter planes and the airships assumed a more defensive role.[3]

The U.S. was not the only country to use airship technology during World War II. Japan used LTA technology in the form of incendiary bombs called Fu-Go, which were floated across the Pacific using balloons. Approximately 1,000 Fu-Go landed within the U.S.,[5] but the bombs were not very effective, killing only 5 civilians who accidentally happened upon a fallen balloon at a family picnic. Interest in LTA vehicles dropped off after World War II and the U.S. Navy airship program was stopped in 1962.[6]

In the 1980s, LTA vehicles received a new lease on life with the use of several tethered aerostats for counter-narcotics and drug interdiction missions on the U.S. border and in the Caribbean.[7] As the U.S. engaged in conflicts where airspace was less contested, such as Iraq and Afghanistan, interest increased in the development and use of LTA vehicles for multiple purposes. For example, tethered aerostat platforms have been highly successful at providing persistent ISR and force protection capabilities at forward-operating bases and even smaller tactical units in OIF and OEF. Additionally, senior military officials are interested in developing airships for logistics transport and believe such ships would enable “rapid deployment of forces to world hotspots.”[8]

Today, LTA vehicles are used by all branches of the armed services and a number of other government agencies requiring persistent ISR capabilities. Moreover, efforts are under way to develop airships capable of airlift and logistics capabilities.

Vehicle Classification

LTA vehicles fall under two primary classes: unpowered and powered (Figure 1). Unpowered vehicles include both balloons and tethered aerostats. Powered LTA vehicles are called airships and can be further categorized as either conventional or hybrid design. Conventional airships, commonly known as blimps, rely purely on buoyancy for lift, whereas hybrid airships use their structure or variable thrust direction to create lift by additional means.[2]

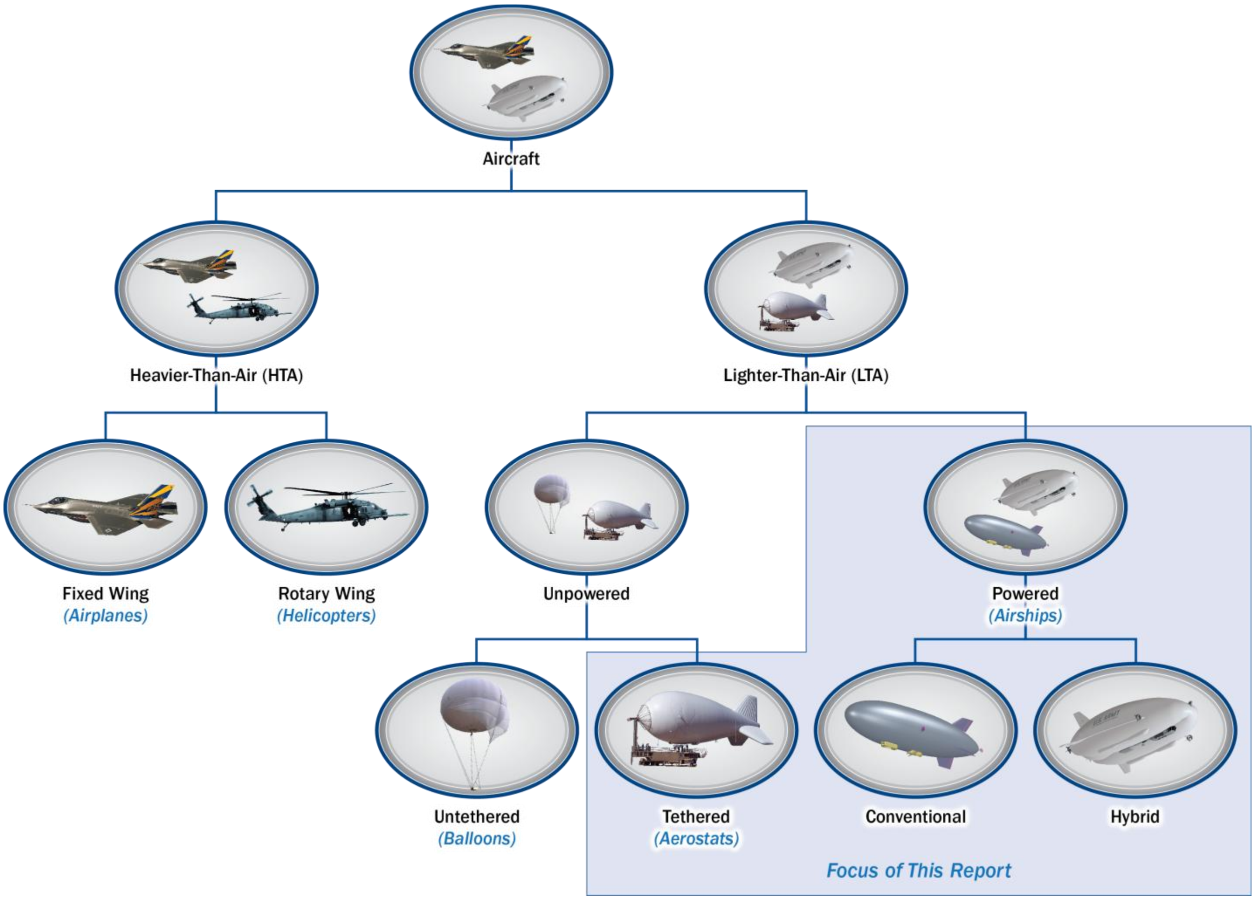


Figure 1: Air Vehicle Categorization[2]

Aerostats

Tethered aerostats are unmanned, non-rigid, LTA vehicles that remain anchored to the ground by one or more cables (Figure 2). The main tether not only holds the aerostat in position but also typically provides power to the aerostat's payload and a data link to provide communications between the payload and the ground control station. The main envelope of an aerostat is filled with helium, while the stabilizing tail fins are normally filled with air. The payload is located in a ventral dome under the envelope. The aerodynamic shape of the envelope and the tail fins provide a stable platform in the presence of modest winds and gusts. When moored to the

ground, large aerostats are anchored to a rotating mast so they can freely weathervane in the wind.[9]

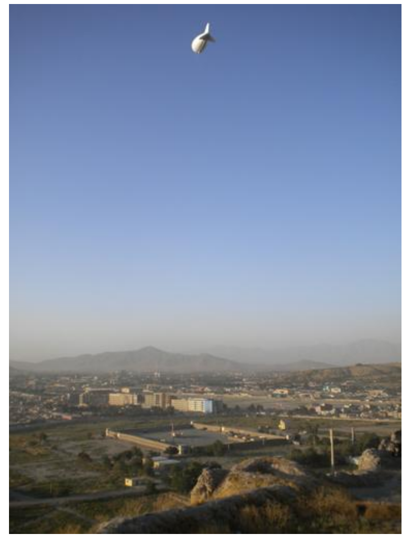


Figure 2: Example of a Tethered Aerostat, PTDS over Kabul, Afghanistan[10]

Airships

Conventional and hybrid airships are classified based on how they generate lift, their hull structure, and how they are piloted.

Lift Mechanism

The primary means by which we will classify airships is by their mechanism for generating lift. A conventional airship is an LTA vehicle that generates virtually all of its lift by the static buoyancy of a contained lifting gas, usually helium.[11] The MZ-3A and Blue Devil 2 airships are examples of conventional airships. By contrast, hybrid airships combine static (buoyant) lift with the dynamic lift generated by aerodynamic effects induced by some combination of vertical and horizontal thrusters (Figure 3). The distribution of lift is typically 70% static and 30% dynamic, stemming from airflow over the aerodynamic hull.[11] This combination allows the vehicle to fly heavier-than-air (HTA) but requires an obstacle-free takeoff area, much like an airplane, to generate dynamic lift when loaded to HTA configuration. The only two hybrid airships currently under development by the DoD are the LEMV and Pelican vehicles.

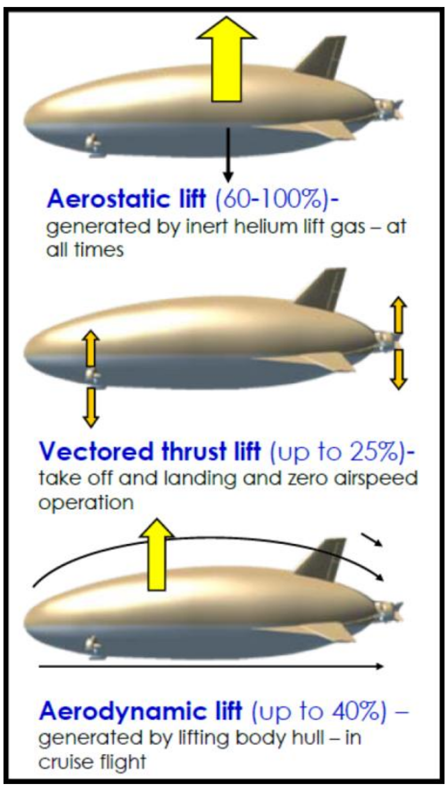


Figure 3: Methods of Dynamic Lift Obtained by Hybrid Airships[12]

Hull Distinctions

The hull, or frame, of an airship can range from a fabric envelope with no structure when deflated (non-rigid) to a hard structure that maintains its shape (rigid). A rigid airship's frame maintains envelope shape, distributes lift and load weight and is of a monocoque, semi-monocoque, or unibody construction. Semi-rigid airships have a structural "keel" to distribute loads, but the envelope shape is maintained via slightly pressurized gas. A non-rigid airship has no frame, such that the structural shape is maintained solely via slightly pressurized gas.[2] The flexible structure may contain a Ballonet, or an air-filled bladder inside of the main envelope, to maintain the external shape of the envelope during ascent and descent. Ballonets are typically paired and located fore and aft inside of the envelope.

Piloting

Airships can be manned, unmanned, or both (optionally manned). The majority of the airships in development by the DoD are pursuing station times on the order of days or weeks, so they are

designed to operate primarily as unmanned vehicles. However, most will include an optionally manned mode that can be used during testing or transport between stations.

Military Applications

There are two primary mission areas for which LTA technology (aerostats and airships) can be applied: ISR and logistical airlift.

ISR

ISR missions are conducted to systematically observe an area and collect information to be analyzed and provide intelligence. ISR applications are frequently characterized by a need for persistent, long-duration surveillance over an area, an application well suited to LTA vehicles. LTA vehicles used for ISR lack air defenses and only carry payloads containing appropriate sensor and communications packages.[4]

Airship ISR aircraft are categorized as high-altitude ISR (>60,000 ft. MSL), or low-altitude ISR (<20,000 ft. MSL). The capabilities of these airships vary greatly, and a wide range of ISR and communications technical offerings exist, as shown in Figure 4. Aerostats are primarily utilized in ISR operations to secure a battlefield and monitor-denied areas and provide border patrol surveillance. As they are tethered platforms, they have no application for logistics missions. Extended range communications is commonly a secondary application for these stationary ISR platforms.

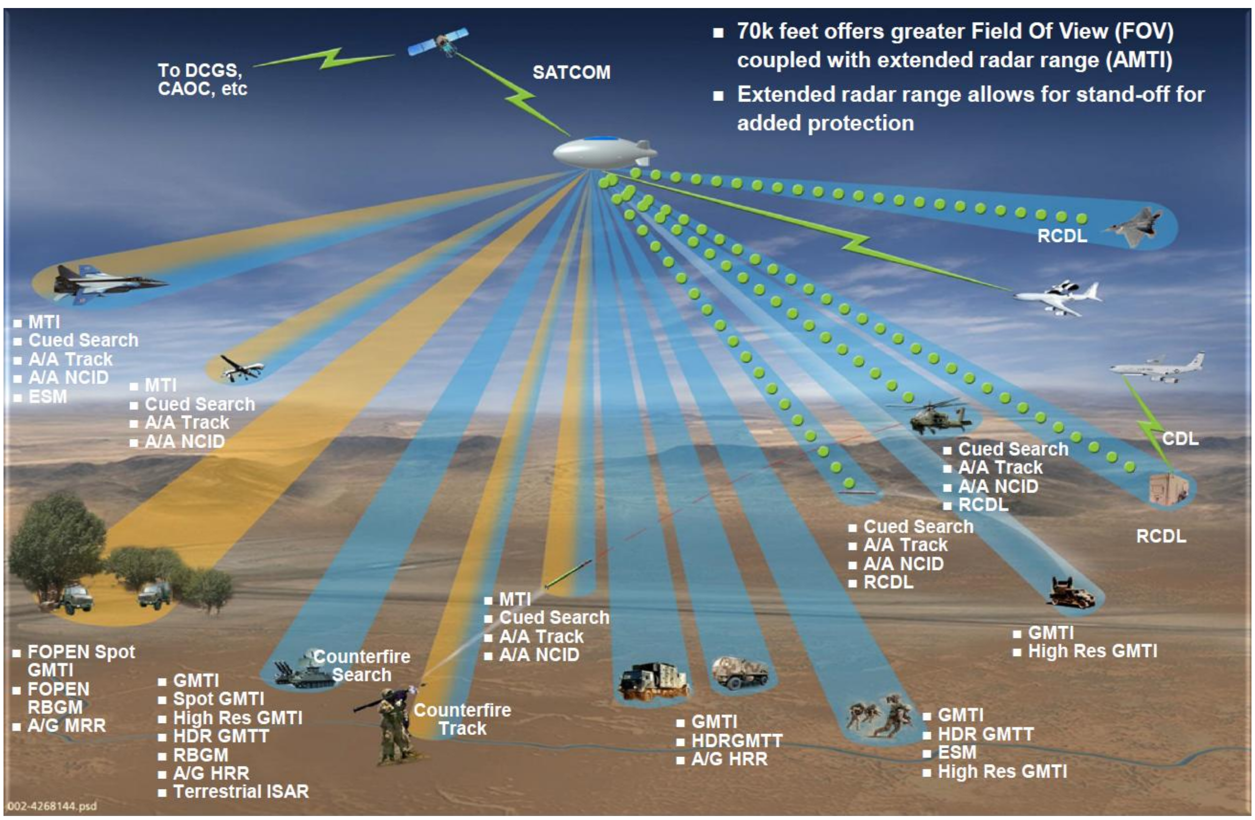


Figure 4: Example of LTA Vehicle Applications in ISR Mission Set[12]

Airlift

Airships, particularly hybrid airships, are in development for airlift applications. The current DoD efforts in this arena are still in the developmental stages, but several concepts and platforms exist in industry. Airlift applications will provide the ability to move cargo and/or people within or between combat theaters.[4] Hybrid aircraft in development are projected to carry large payloads with greater fuel efficiency when compared with conventional HTA aircraft. While they operate at slower speeds than conventional fixed-wing aircraft, they are projected to move large loads with greater speed than land and sea methods. Hybrid airships fill a gap in the cost-versus-speed analysis shown in Figure 5.

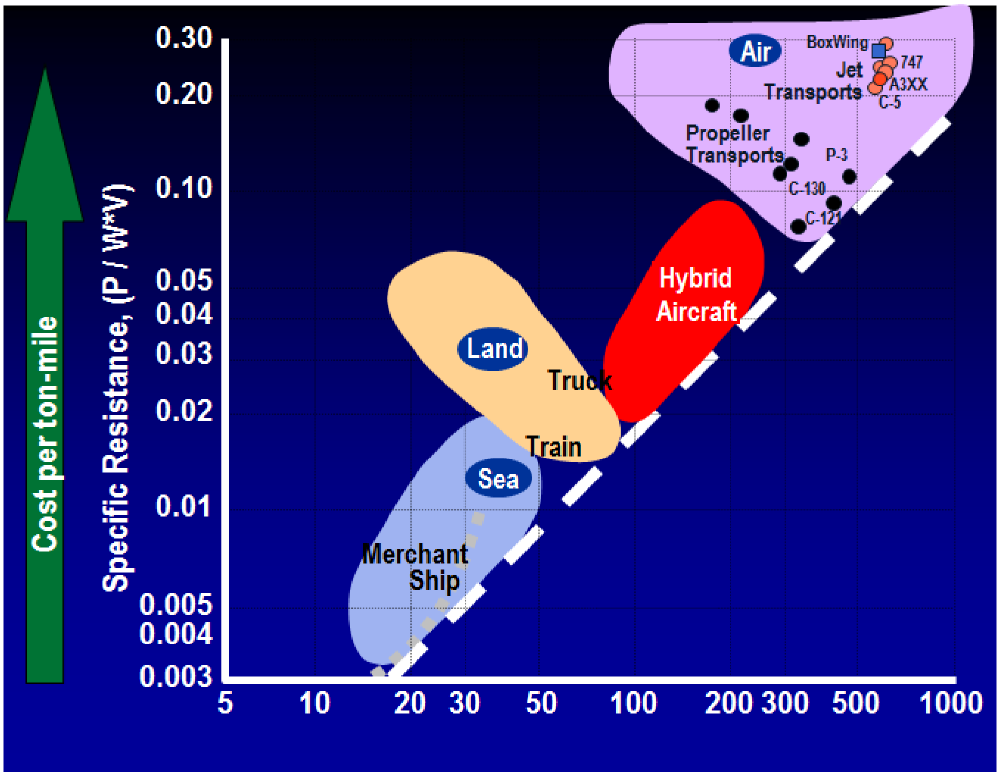


Figure 5: Cost-Speed Comparison for Airlift Vehicles[13]

Current DoD Usage

Aerostats and airships are currently utilized or developed by all services of the military and by organizations under the OSD (Figure 6). The Navy's MZ-3A is the only fully developed airship currently operational and maintained by the DoD; however, the Army, Air Force, DARPA, and ASD(R&E) are actively pursuing a range of conventional and hybrid airships intended for ISR and airlift applications.

The MZ-3A is a conventional airship, capable of low-altitude ISR applications, but it is primarily used as a flying laboratory to test and develop ISR sensor payloads.

The SMDC recently concluded two programs (HALE-D and HiSentinel), that developed conventional airship technology demonstrators for high-altitude ISR applications. The SMDC is currently focused on the development of the LEMV hybrid airship, which is to be deployed for

low-altitude surveillance. When completed, the LEMV will be the first DoD hybrid airship to be operationally deployed.

DARPA has conducted several development efforts in the last 10 years to advance airship technology. Three of these efforts have been combined to form the Pelican (RAVB) program conducted by ASD(R&E) and NASA. The Pelican airship is a hybrid airship technology demonstrator designed to test several technology achievements required to develop a larger-scale hybrid airship for airlift operations. DARPA is currently working on the ISIS program, which is producing a sub-scale conventional airship as a technology demonstrator for an innovative high-altitude ISR airship that integrates the sensor payload into the structure of the airship.

Aerostats are a more mature technology than airships. As such, several DoD efforts have deployed aerostats to support multiple missions, including wide area surveillance for offensive and defensive roles, force protection and cruise missile detection in ISR and border security missions. The Army is the most prolific user of aerostat systems, with a half dozen separate on-going programs. The Navy works with the Army on the REAP program and the Navy effort, PGSS, is transitioning to the Army to merge with the existing PTDS program under the new name PSS-T. The Air Force also operates the TARS program, which provides border security in the United States.

Figure 6: Air Vehicle Efforts by Organization

AEROSTAT PROGRAMS

Aerostats are air vehicles that utilize buoyant LTA gases to achieve lift and remain aloft for extended periods of time. Aerostats are composed of four primary components: aerostat, tether, mooring station and payload. In modern military use, aerostats are recognized as cost-effective, survivable systems capable of providing enhanced ISR, communications and force protection capabilities to numerous operational scenarios. Aerostat capabilities are dependent upon a number of factors, including aerostat size, mooring station altitude, atmospheric conditions, and payload weight. A range of system configurations have been developed since the 1980s to meet a variety of operational needs.

Early systems were developed to enable target identification and tracking of small aircraft and other narcotics-drug traffic along the U.S.-Mexican border. While these systems are still in use today, no new developments in aerostats occurred until the onset of the wars in Iraq and Afghanistan. At the beginning of the Iraq war in 2003, commanders soon found themselves subject to high levels of gun fire and rocket-propelled grenade attacks at the Baghdad International Airport and other high-travel locations in Iraq. In 2004, aerostats, equipped with cameras and sensor payloads, were raised at these locations to help locate and identify the attackers. They proved highly effective at reducing the number of daytime attacks and also at observing nighttime activity, demonstrating their ability to provide valuable ISR information and track enemy forces.[14]

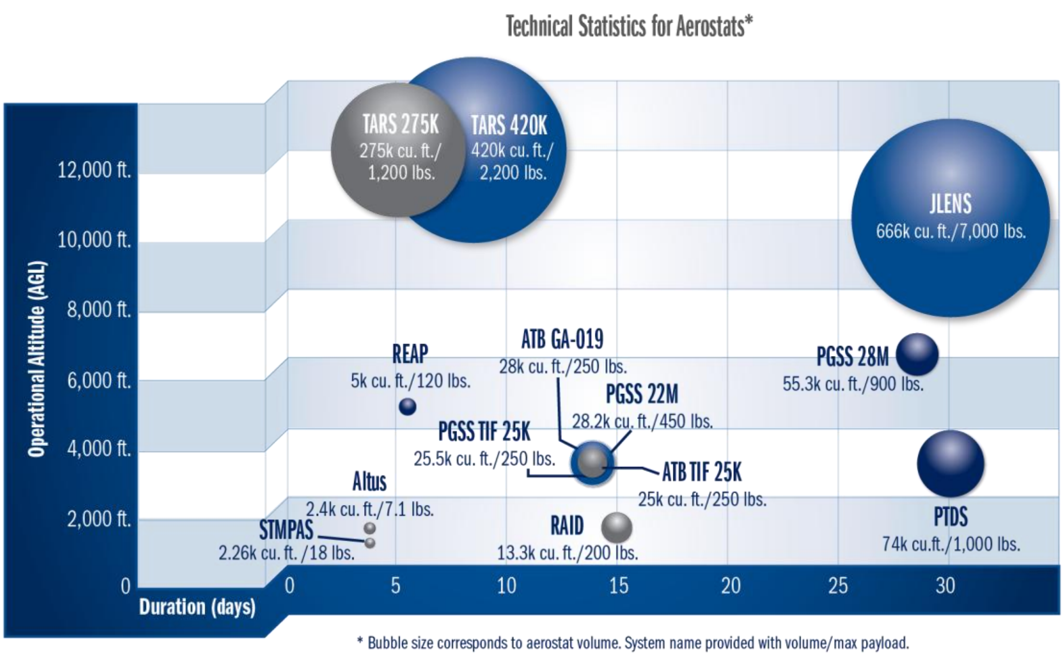


Figure 7: Operational Altitude (AGL), Duration, Volume, and Max Payload Specifications for DoD Aerostats

The increase of troop levels in OEF led to increased casualties as a result of roadside bombs and improvised explosive devices (IEDs) used by insurgents. Field commanders initiated numerous requests for enhanced persistent ISR capabilities, and aerostats helped fill this capability gap. [14] Over the course of OEF, smaller and more mobile aerostat systems were developed to provide enhanced ISR and force protection for large FOBs down to small mobile combat units. As requirements for smaller and more mobile systems emerged, the Army conducted comparative testing of new aerostat systems to provide capability assessments and ensure the most cost effective systems are being pursued. Aerostat development programs following the initial deployment in OEF have sought to ensure the highest priority science and technology challenges for aerostats are being addressed by enhancing payload capabilities, reducing payload size weight and power requirements, developing enhanced lifting concepts with smaller system volumes, and enabling transfer of capabilities to smaller more mobile tactical units. The Altus, REAP XL B and STMPAS systems are examples of efforts being made to overcome the technical challenges associated with providing organic surveillance capabilities to mobile forces such as tactical units and command operating posts. These smaller systems seek to employ advances in low weight sensor systems and/or use innovative tailfin configurations to increase lift and maximize payload capacity. The PTDS, PGSS, and JLENS programs are actively working to utilize the most advanced sensor systems and/or create highly responsive sensor communication networks to enable rapid target identification, tracking, and engagement. The following section provides a summary overview of all actively funded aerostat programs within the DoD.[14] Figure 7 provides an overview of the range in duration, operational altitude referenced to MSL, payload capacity and aerostat volume found in current DoD aerostat systems.

Aerostat Test Bed (ATB)

Table 2: ATB Program Overview	
Vehicle Class: Aerostat **Mission Set:** Test bed **Organization:** Army SMDBL **Primary Contractors:** Quantum Research Intl. **Program Start:** 2007 **Technology Readiness Level (TRL):** 7	 **Figure 8: Underside of the ATB at Altitude**[15]

The objective of the ATB is to: (i) plan, provide, and operate aerostats as high-altitude surrogate platforms in support of payload development and testing (e.g., sensors and communications), and (ii) provide and operate aerostats as elevated communications and/or sensor platforms in support of DoD, homeland defense, and other regional and national experiments, exercises, and demonstrations.[16] The aerostats provide a safe and cost-effective test bed for lifting payloads before testing those payloads at high-altitude on expensive stratospheric vehicles.[16]

The Army Space and Missile Defense Battle Lab (SMDBL) makes available and provides the ATB as a national resource for test and evaluation events for a variety of payloads during development and testing (i.e., sensors and communications). This service is intended to be performed with simple coordination efforts, and the Battle Lab manages all logistics associated with ATB operations, including deployment, labor, helium and parts, electrical power and fiber optic connectivity up the tether to the payload bay. ATB support is low cost and easy to coordinate. Customers who seek to test a payload at high-altitude engage with SMDBL for use of the ATB, and SMDBL works to coordinate, organize and run a test event. SMDBL operators will support the intellectual capital of partner organizations to further the development of the high-altitude regime and partner objectives.[17]

SMDBL owns two complete aerostat systems, which comprise its ATB operation: a Lindstrand GA-019 (28,000 cu. ft.) and an Aerostar/Raven TIF 25K (25,000 cu. ft.). Each system is equipped with envelope, mooring gantry trailers, and logistics services (e.g., operations center support trailer, power generators, and tow vehicles).

The two systems can operate as a combined setup or independently at different locations. The systems feature an easy-to-install and integrate (power and fiber optics) payload interface to enable rapid mounting and payload elevation to altitude. Depending on the size and scope of the test event, the ATB requires 3 to 12 operators. The primary testing facility is located in Colorado Springs but is able to deploy anywhere in CONUS (contiguous United States). The Lindstrand aerostat system is C-130 transportable and, therefore, has an expanded deployment range. SMDBL has

Table 3: ATB Technical Specifications		
	TIF 25K	**GA-019**
Length	75 ft.	83 ft.
Diameter	28 ft.	28 ft.
Volume	25,000 cu. ft.	28,000 cu. ft.
Max Payload	Up to 250 lbs.	Up to 250 lbs.
Manufacturer	Aerostar	Lindstrand
Duration: Up to 14 days (without top off) **Flight Ceiling:** 3,000 ft. AGL at sea level and less at higher launch elevations. Altitude dependent on payload weight and weather factors. **Crew:** 3–12 per system **Payload Type:** various (COMMS, ISR, scientific research, other)		

supported Army Expeditionary Warrior Experiment (AEWE) and NIE events over the past 3 years.[17]

The first system was originally purchased in January 2007 with congressional grant appropriations to support aerostat requirements for DoD and U.S. Department of Agriculture projects.

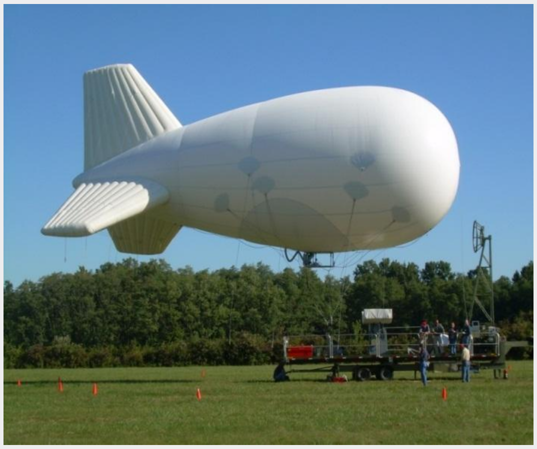


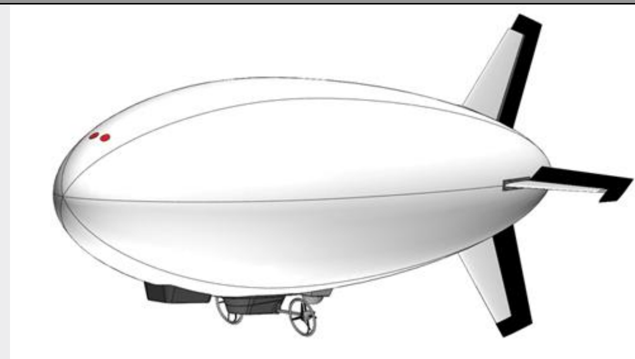
Figure 9: ATB During Inflation[15]

The first system was then transferred to Battle Lab management in 2010. The ATB is a Government-funded, contractor-operated platform with funds coming from SMDBL and Quantum Research International operating the aerostat. The system is fully mission ready and capable of performing test flights when needed. At NIE 12.1, ATB lifted 250 lbs. to between 1,200 and 1,400 ft. above ground level (AGL) for 3.5 weeks with a classified communications payload. The next planned program event is the NIE 13.1 (terrestrial connectivity to aerial tier) and LaserComm in the summer of 2012. No technical or programmatic challenges currently exist within the ATB operation.[17]

Figure 10: Payload Bay of the ATB[15]

The ATB program began in FY07 with congressional grant appropriations to SMDBL. Currently, the program is in the sustainment phase and SMDBL plans to execute the program using customer funds as testing requires.

Altus

Table 4: Altus Program Overview	
Vehicle Class: Hybrid Aerostat/Airship **Mission Set:** ISR/Force Protection **Organization(s):** Army REF **Primary Contractors:** Silicis Technologies Inc. **Program Start:** 2011 **Technology Readiness Level (TRL):** 6	 **Figure 11: Computer Rendering of Altus System**[18]

The technical objective of Altus is to enhance a unit's persistent surveillance capabilities. Small units will have the ability to monitor the immediate area, provide reconnaissance beyond obstacles and remotely identify targets of interests. System will provide early warning of threats and insurgent operations. The system will be operated by soldiers rather than contractor field service representatives (FSRs) and must be deployable by CH-47 or similar to remote locations.[18]

An important key differentiator is that the Altus is a hybrid platform, capable of operation as a tethered aerostat or as an unmanned airship. The system includes significant automation of both the inflation process and the flight controls and can be deployed by a 4-man team with a relatively short training cycle. Altus is highly portable compared to typical aerostats, with most components carried in four pelican cases in addition to an MEP-831A generator and a winch. Lightweight helium cylinders are also included with the system, although High Pressure Cylinder Assemblies will likely be used in OEF due to the existing supply chain. The highly automated system is capable of unmanned airship or aerostat operation with a radio frequency (RF) data link to provide full-motion video (FMV) from an on-board Electro-Optical/Infrared (EO/IR) camera system.[18, 19]

System flight dynamics are still under evaluation to determine stability in unfavorable wind conditions and may require changes to the control surfaces. Airship mode has not been formally evaluated at this time as it will require a certificate of airworthiness prior to operation without a tether and will also require operators trained to Army Requirements (AR) 95-23 standards. This training requirement may not be compatible with the intent to allow small units to utilize the system with minimal advance preparation.[18, 19]

Silicis is currently partnering with DRS Technologies, Inc. to field the DRS205 Electro-Optical/Infrared/Laser Designator/ Laser Range Finder (EO/IR/ LD/LRF) Targeting System, which employs the latest in sensor technology and provides a small, lightweight, sensor system for small Unmanned Aircraft (UA) and aerostats. This sensor system enables the UA or aerostat

Table 5: Altus Technical Specifications	
 Figure 12: Underside of Altus During Flight[18]	
Length: 35 ft.	**Flight Ceiling:** 1,250 ft. AGL (up to 7,500 ft. MSL ground elevation and 95º F)
Diameter: 12 ft.	**Duration:** 2–4 hours (airship mode), 4 days (aerostat mode only & without top-off)
Volume: 2,400 cu. ft.	**Crew:** 4
Max Payload: 7.1 lbs.	**Cruise Speed:** 10 kts. (airship mode only)
Payload Type: EO/IR with LRF & pointer, Laser Designator optional	**Max Speed:** 25 kts. (airship mode only)

operators, along with other networked elements of the Combat Team, to have real-time "eyes" on the battlefield situation and make real-time decisions regarding detection, location and immediate prosecution of threats. The GS205 EO/IR/LD/LRF system gives the platform a day and night capability for reconnaissance, surveillance, target acquisition and location, along with the capability to accurately bring laser-guided weapons to bear on targets.[19]

Partnering with Ultra Electronics MSI, the Altus will have the ability to pass control from a traditional command and control system to a dismounted/off-base tactical, man-portable operator control unit (OCU). The self-contained, handheld OCU increases mission persistence, protection and presence through a lightweight, low-power, integrated computing environment that includes solid state storage and networking support.[19]

Altus was initiated in December 2011 by Army Rapid Equipping Force (REF) to provide an affordable, small-scale, mobile aerostat platform for ISR and force protection support to small operational forces deployed in remote and austere FOBs or Command Observation Posts (COPs) that

would otherwise lack organic surveillance capabilities.

Silicis Technologies is working with the DoD to provide two Altus systems. The two Altus systems are being acquired for testing and forward operational assessment. System 1 has been delivered and is currently being tested at the Electronic Proving Ground, Fort Huachuca, Arizona to obtain a safety confirmation and verify performance capabilities. First flight has been completed. A CONUS user evaluation is planned at the Maneuver Battle Lab, Fort Benning, Georgia to obtain soldier feedback on the system. Following the user evaluation, one system is tentatively planned to participate in NIE 13.1 and the other will be deployed in OEF to begin the operational assessment. Altus has also been accepted for participation in the upcoming Army Expeditionary Warrior Experiment Spiral H, to take place at Fort Benning, Georgia, January through February of 2013. Altus is currently at a TRL 6. [18, 19]

Altus began in FY12 with funding from Army REF. Current plans are to evaluate system performance before any additional procurement actions.

Joint Land Attach Cruise Missile Defense Elevated Netted Sensor System (JLENS)

Table 6: JLENS Program Overview	
Vehicle Class: Aerostat **Mission Set:** ISR **Organization:** Army lead, Joint Interest **Primary Contractors:** Raytheon **Program Start:** 2005 **Technology Readiness Level (TRL):** 7	 **Figure 13: JLENS in Moored Configuration**[20]

The objective of the JLENS is to provide persistent surveillance and tracking capability for unmanned aerial vehicle and cruise missile defense to the current and projected defense forces. JLENS uses advanced sensor and networking technologies to provide 360-degree, wide-area surveillance (WAS) and precision target tracking. This JLENS information is distributed via Joint service networks and contributes to the development of a single, integrated air picture. JLENS will provide fire control quality data to surface-to-air missile systems, such as Army Patriot and Navy Aegis, increasing the weapons' capabilities by allowing these systems to engage targets normally below, outside or beyond surface-based weapons' field of view. Additionally, JLENS provides this fire control quality data to fighter aircraft, allowing them to engage hostile threats from extended ranges. JLENS also detects and tracks surface moving targets and provides this data on multiple networks. JLENS provides launch point estimate for tactical ballistic missiles and large caliber rockets.[21]

A JLENS Orbit consists of two systems: a fire control radar system and a WAS radar system. Each radar system employs a separate 74-meter tethered aerostat, mobile mooring station, radar and communications payload, processing station, and associated ground support equipment. A JLENS battery consists of 128 personnel for operation of one orbit based on current Table of Organizational Equipment (TOE). There are two temporary test sites at Utah Test Training Range (UTTR) and one temporary test site at White Sands Missile Range (WSMR). Raytheon is the primary contractor working with the DoD to provide two Engineering and Manufacturing Development (EMD) orbits (1 orbit consists of 2 aerostats—one for fire control, and one for WAS).[21]

The JLENS Operational Requirements Document (ORD) calls for initial fielding to Block I requirements (tethered aerostat platforms for Fire Control and Surveillance radars), followed by fielding of Block II (untethered platforms for Fire Control and Surveillance radars) and Block III (both radars on a single untethered platform).

Table 7: JLENS Technical Specifications	

Figure 14: JLENS Configuration[20]

Length: 243 ft.	**Payload Type:** Radars and COMMS
Diameter: 94.5 ft.	**Flight Ceiling:** 10,000 ft. MSL
Volume: 666,068 cu. ft.	**Duration:** 30 days
Max Payload: 7,000 lbs.	**Crew:** 1 orbit requires 78 personnel to operate

There is currently no funding beyond Block I.[21]

The JLENS systems located at the UTTR and WSMR made significant technical progress during 2011. The Surveillance System (SuS) completed a successful Functional Verification Test (FVT)-2, and both 7-day and 14-day endurance tests. Both the Surveillance Radar (SuR) and the Fire Control Radar (FCR) successfully conducted Link-16 and Cooperative Engagement Capability operations. Key components of JLENS EMD Orbit #1 were integrated in preparation for the start of developmental testing (DT). JLENS successfully conducted two Integrated Fire Control (IFC) Ground Integration and Checkout (GIACO) Campaigns at UTTR during the weeks of 29 August 2011 and 26 September 2011. Targets were successfully flown and IFC missions with the Patriot system were conducted. During testing, the surveillance system successfully provided target cuing information to the fire control system (FCS),

and Identification Friend or Foe (IFF) modes 1, 2, and 3 were successfully executed. JLENS successfully completed 22 of 23 (96%) DT-1 missions from 07 November 2011 to 16 December 2011. The JLENS radars successfully tracked fighter aircraft and towed targets and cruise missile targets, meeting accuracy requirements within margin. The formal testing demonstrated successful IFF using several detection modes (1–3). JLENS tracks were successfully integrated into the Hill Air Force base Link-16 network and a local network that included counter-rocket, artillery and mortar forward area air defense command and control as well as sentinel radars. Target handovers were executed to a tactical Patriot radar system via Link-16. In between periods of formal testing, testing was conducted to progress non-cooperative target recognition, IFF Mode 4, unmanned aerial vehicle (UAV) and surface-moving target tracking capabilities. This accomplishment provided data to conduct of an IFC mission with a Patriot Advanced Capabilities-3 (PAC-3) missile in April 2012. [21]

The program incurred a significant Nunn-McCurdy cost and schedule breach in 2011. The breach was due to a 2010 decision to extend the program 6 months as part of the Army's overall strategy for integrated air and missile defense. Engineering challenges associated with prime item integration and delays to developmental testing caused by the destruction of a prototype aerostat during severe weather at the contractor's manufacturing facility further contributed to the delay. As a result of the 6-month delay, the program acquisition unit cost exceeded 15% (17.88%), which triggered the breach.[21]

The JLENS Product Office and the Lower Tier Project Office recently conducted a successful detect, track and shoot down of a low flying, long-range drone target at the UTTR on 25 April 2012. This demonstrated the unique ability to detect, track, engage and destroy a cruise missile target at extended range in an integrated air and missile defense architecture that joins netted sensors and missile defense systems.[21]

Plans for FY12 include completing software development/integration/testing and continuing DT, including a PAC-3 IFC mission. The Army will complete the JLENS EMD program to complete testing and maintain a viable option to begin procurement at milestone (MS) C. On-going study and analysis could potentially result in JLENS participation in an operational assessment in support of a Combatant Command (COCOM) Exercise in the near term.

Persistent Ground Surveillance Systems (PGSS)

Table 8: PGSS Program Overview	
Vehicle Class: Aerostat **Mission Set:** ISR **Organization:** NAVAIR, Army G-2 **Primary Contractors:** Raven, TCOM, L-3 Wescam **Program Start:** 2009 **Technology Readiness Level (TRL):** 8	 **Figure 15: PGSS in Moored Configuration**[22]

The objective of PGSS is to provide continuous, real-time ISR, force protection, FOB protection, and oversee support to the FOBs throughout OEF. The system is utilized by FOB commanders to observe attack preparation, IED emplacements and insurgent activities such as hostage taking and car hijackings. The cameras have a range of approximately 18 km (360° around the aerostat) and can be combined with other sensors, such as shot detection monitors, to locate live fire.[23]

Sensor payload configurations can include: EO/IR cameras (Wescam MX-15 or FLIR 380 HD), wide area surveillance systems (WASS), expendable unattended ground sensor (EUGS), COMMS packages, Unattended Transient Acoustic Measurement and Signature Intelligence (MASINT) Sensor (UTAMS) small arms fire detector, and radar systems. There is no one standard payload suite, but common interfaces allow swapping capabilities and versatility in the field. PGSS is supplemented with tower systems in order to enable system recovery and repair if needed.[23]

Three PGSS variants have been developed based on different platforms: the TIF 25K, the TCOM 22M, and the TCOM 28M. Differences between systems are shown in Table 9. All systems are at a TRL 8. Power is provided to payloads via the tether. No hangar is required for PGSS, but a 200- to 250- ft. diameter clearance is needed for launch and recovery depending on the aerostat size. PGSS has wind restrictions of 10 kts. during inflation, 30 kts. during mooring, 25 kts. during helium top off and is capable of conducting flight operations in up to 50 kt winds.[23]

PGSS was started as a Joint Capability Technology Demonstration (JCTD) program in response to urgent United States Forces-Afghanistan (USFOR-A) requests to cover critical shortfalls in Persistent Surveillance. Joint Requirements Oversight Council (JROC) validated the requirement to support the Joint Urgent Operational Needs Statement (JUONS). Army G-2 provided and OSD provided funds for the JCTD. NAVAIR was tasked to lead the effort, while Army G-2 REF provided funds. The prime contractor initially selected to make the aerostat balloons was Raven Aerostar. Aerostar's TIF 25K model aerostat was initially selected as the platform and was followed by TCOM's 22M model aerostat.[23]

Table 9: PGSS Technical Specifications			
	TIF 25K	**TCOM 22M**	**TCOM 28M**
Length	75 ft.	76 ft.	99 ft.
Width	25 ft.	29 ft.	38 ft.
Height	25 ft.	35 ft.	46 ft.
Volume	25,500 cu. ft.	28,200 cu. ft.	55,300 cu. ft.
Max Payload	250 lbs.	450 lbs.	900 lbs.
Duration	14 days	14 days	28 days
Flight Ceiling: 6K–9K ft. MSL **Crew:** 6–8 per system (contractor) **Payload Options:** Wescam MX-15 HDi, FLIR 380 HD, UTAMS, COMMS relay packages, EUGS, WASS Max Payload (dependent on MSL pad elevation)			

Figure 16: Underside of PGSS Showing Payload Support[24]

Development, assessment and subsequent delivery of the first PGSS system to theater was completed within 6 months of program inception. The Army G-2 then authorized purchase of additional systems. The PGSS program is currently delivering new systems and capabilities, while sustaining existing systems. The PGSS Program met and is currently achieving cost, schedule, and performance goals. Each system requires a crew of 7 for the TIF 25K and TCOM 22M models, while the TCOM 28M requires 8 personnel. FSRs are allocated on a need-by-need basis and depend on the component in need of repair. TCOM is now the primary platform provider. L-3 Wescam provides the main EO/IR sensors for PGSS and forward looking infrared (FLIR) cameras are currently being tested and deployed. As of this report, 59 systems have been delivered to the OEF theater of operations.[23]

Programmatic challenges have included high crew attrition rates due to austere FOB conditions. This is being addressed by supplementing sites with additional crew members and providing accelerated training. Other challenges include difficulties with logistics and supply chains for components, platforms, and helium movement within theater. High helium demand is hindered by low supply or limited access due to unsecured supply lines. Continuous process improvement and lessons learned in theater are used to mitigate supply issues. Current program plans are to continue providing ISR and force protection capabilities to FOBs

and advance systems capabilities as new technology becomes available.[23]

As the war in Afghanistan winds down, PGSS will begin transition to other foreign and domestic government agencies. The persistent ISR capabilities of this system make it viable in a variety of operations, such as border patrol, port and harbor patrol, and more.

The Army and OSD provided initial funding for PGSS in FY09 with NAVAIR leading the initiative. The PGSS program will be combined with PTDS under PM MaTIC and that transition is to be completed by 2014.[23]

Persistent Threat Detection System (PTDS)

Table 10: PTDS Program Overview	
Vehicle Class: Aerostat **Mission Set:** ISR **Organization(s):** Army ASA(ALT), PEO IEW&S, PM MaTIC **Primary Contractor(s):** Lockheed Martin **Program Start:** 2004 **Technology Readiness Level (TRL):** 8	 **Figure 17: PTDS 74K Aerostat System**[25]

The objective of PTDS is to provide long-endurance and real-time ISR, force protection, FOB protection, and route C-IED support to the FOBs throughout OEF.[26]

PTDS consists of an aerostat, tether, mobile mooring platform, mission payloads, ground control shelter, maintenance/office shelter, tactical quiet generators and site-handling equipment. Specific system configuration is dependent upon individual mission need. However, all systems provide a dual cross-cueing sensor payload consisting of either dual MX20 EO/IR sensors; 1 MX 20 and 1 STARLite ground and dismount moving target indicators (GMTI/DMTI) Radar (deployed for PTDS in April 2011; or 1 MX20 and 1 Kestrel WAS. [26]

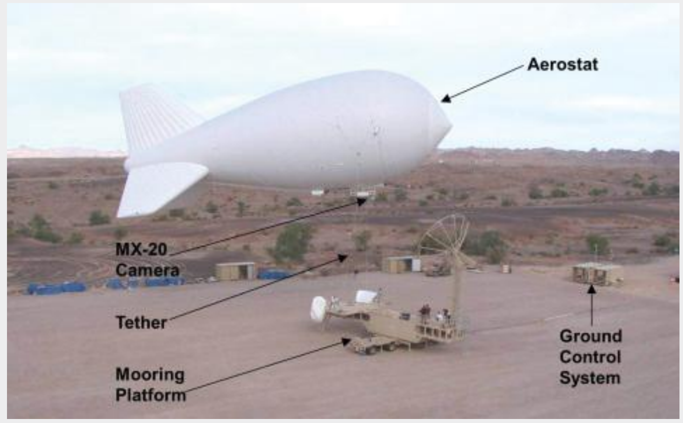
Baseline configuration also includes the U.S. Army Research Laboratory's (ARL) UTAMS, and a Persistent Surveillance Dissemination System of Systems (PSDS2) for FMV dissemination through a network interface. [26]

The full list of PTDS sensor payload configuration options include dual MX 20 high definition (HD) EO/IR camera (provides real-time FMV, high-magnification FLIR thermal imager, slew to cue from UTAMS or other sensors, range >24 kilometers (km); MX20 and STARLite GMTI/DMTI radar, or MX20 and Kestrel EO/IR WAS. [26]

Communication configuration includes High Antennas for Radio Communications (HARC) radio, PRC-117G, Tactical Targeting Network Technology (TTNT), Highband Networking Radio (HNR), Air Force Weather Agency (AFWA) weather relay kits, Mini-Tactical Common Data Link (M-TCDL) transmitter (Transmits MX-20 video stream to ground forces equipped with One System Remote Video Terminal (OSRVT)), UTAMS (operationally cues the PTDS MX-20 to slew onto a target). [26]

Utilizing these payload options, PTDS capabilities include:

- Secret Internet Protocol Router Network (SIPRNet) video dissemination via PSDS2
- Laser illuminator/pointer for use by ground forces

Table 11: PTDS Technical Specifications	
Length: 117 ft. **Width:** 39 ft. **Height:** 39 ft. **Diameter:** 52 ft. **Volume:** 74,000 cu. ft. **Max Payload:** 1,000 lbs. **Payload Options:** MX-20 EO/IR, UTAMS, STARLite GMTI/DMTI, Kestrel WAS **Flight Ceiling:** 8,000 ft. MSL / 3,000 ft. ASL **Duration:** 30 days aloft (97% op. avail)	 **Figure 18: PTDS Subsystem Components[10]** **Crew:** 8 for single sensor, 10 for dual sensor

- GMTI/DMTI wide area, near-real-time reconnaissance, surveillance, and target acquisition capabilities, operating in adverse weather and through battlefield obscurants
- Extended range platform for Command, Control, Communications, Computers, Combat Systems, Intelligence, Surveillance, and Reconnaissance (C5ISR) systems, Enhanced Position Location Reporting System (EPLRS), Single Channel Ground and Airborne Radio System (SINCGARS), HNR, TTNT, HARC

PTDS was initiated in 2004 as a QRC program by ARL to satisfy a JUONS. The primary contractor is Lockheed Martin, who provides operational support at 66 PTDS sites. The PTDS operations center is located in Melbourne, Florida; the systems integration center is located in Akron, Ohio; and Yuma Proving Ground (YPG), Arizona hosts the PTDS test site. The program is funded with Overseas Contingency Operations (OCO) funds. OCO funds began in FY06. The Acquisition Authority for PTDS is Program Executive Office Intelligence Electronic Warfare and Sensors (PEO IEW&S) and PM MaTIC. The system stakeholders include U.S. Army G-2, USFOR-A, CENTCOM, ISR Task Force, C5ISR Task Force, Training and Doctrine Command (TRADOC), Tobyhanna Army Depot (TYAD), and YPG.[26]

The primary known technical challenge (current and future) is survivability due to environmental factors such as lightning—damage to envelope and payload equipment and microbursts—extreme tether slack and tether catches causing severing/damage. The mitigation strategy for these risks includes supporting JUONS for improved weather forecasting. Approved weather architectures have been installed at 26 PTDS sites, and these sites are currently transmitting weather data to AFWA to better inform weather forecasting. Also, theater flight guidelines have been revised to restrict flight to more conservative conditions, further reducing the likelihood of damage due to weather

conditions. PTDS is also investigating leveraging the PGSS weather web software (Government owned) to provide automatic alerts from AFWA to each site, in addition to sharing real-time weather data between all PGSS and PTDS sites using our current PTDS communication infrastructure. Upgrading every PTDS site with the approved architecture will reduce the risk of negative impact due to weather events.[26]

There are 47 systems currently deployed in OEF as of 1 May 2012, with a total of 65 systems expected to be deployed by 31 July 2012, and 1 system sits at YPG for testing. An 8- to 10- member crew is required per PTDS site for single- and dual-sensor systems, respectively. The program office plans to continue fielding the remaining 19 systems to meet JUONS CC-0306 (August 2012), finalize fielding of weather systems on PTDS to transmit data to the AFWA to meet JUONS CC-0432 (June 2012), upgrade the C5ISR capabilities at 6 PTDS sites (May 2012), upgrade the EO Kestrel WAS to the EO/IR version (by May 2012) to meet Dual Sensor Upgrade JUONS CC-0424, dated 18 August 2010, and continue to support the C5ISR aerial layer program.[26]

On 8 June 2011, the Vice Chief of Staff of the Army (VCSA) approved the Army Requirements Oversight Council's (AROC) Capability Development for Rapid Transition (CDRT) recommendation to transition three existing QRCs into a POR, formally documenting these capabilities and establishing a standardized requirement for an enduring tethered aerostat capability, including training, maintenance and sustainment. The three QRCs are PGSS, PTDS, and PSDS2.[26]

The PTDS program began in FY04 with funding from OSD. On 24 February 2012, an Army Acquisition Executive (AAE) memo assigned acquisition management authority to PEO IEW&S and plans are to continue funding the program through FY16. PM MaTIC and NAVAIR formed an Integrated Product Team (IPT) to transition the PGSS program to IEW&S by FY14. The program office is working to establish the PSS-T POR. After the transition, PTDS, PGSS and PSDS2 will fall under PSS-T, per the AAE memo referenced above. The PSS-T Capabilities Development Document (CDD) was submitted for world-wide staffing in February 2012. Final world-wide staffing is pending.[26]

Rapid Aerostat Initial Deployment (RAID)

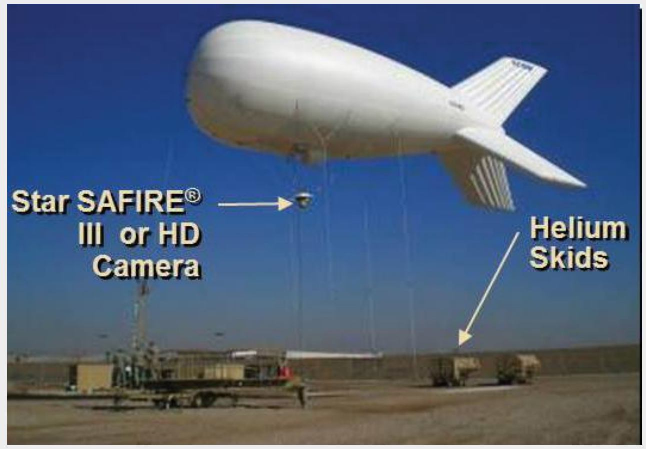
<table>
<tr><th colspan="2">Table 12: RAID Program Overview</th></tr>
<tr><td>Vehicle Class: Aerostat
Mission Set: ISR
Organization(s): Army
Primary Contractor(s): Raytheon
Program Start: 2003
Technology Readiness Level (TRL): 9</td><td>
Figure 19: RAID Aerostat Just After Launch[27]</td></tr>
<tr><td colspan="2"></td></tr>
</table>

The objective of the RAID systems is to provide persistent, panoramic surveillance of the covered area, enabling timely warning of potential threats and other events valued for intelligence purposes.[28]

The aerostat is approximately 66 ft. long, 20 ft. in diameter and can lift up to 200 lbs. to approximately 1,000 ft. AGL (assuming pad at 0 ft. MSL). Pad elevation above 0 ft. MSL results in lower maximum operational altitude. Each aerostat system includes a 14 ft. shelter that houses the controls and sensor display equipment. Additionally, a mooring station with tether, helium skids and support equipment accompany each system. TCOM manufactures the aerostats. RAID can house either a FLIR Star SAFIRE®III or HD EO/IR sensor with laser range finder and designator. Map overlay and camera displays can be viewed at the ground station consoles, but the system is also equipped for network interoperability. Either sensor payload provides 24/7, 360-degree visual coverage of an area. RAID can withstand wind of up to 40 kts. on station, 25 kts. during launch or recovery and 55 kts. while moored. No hangar is required. A 100 ft. radius is needed for the mooring station and launch and recovery. For 24-hour operation, 12 operators are required per system with 1 FSR required per 3 systems.[28]

The operational needs statement (ONS) for the RAID program was started on 1 February 2003 in order to help protect U.S. forces against IED emplacements and insurgent attacks during OIF. The RAID program was a component of JIEDDO's detection activities supporting the Defeat the Device mission. Between 2003 and 2011, 19 operational systems were deployed in OIF and OEF. The 19 systems are currently being stored at the Kuwait Reset Facility, and two additional systems are kept at Redstone Arsenal for training, for a total of 21 systems. The primary contractor supporting the RAID program is Raytheon, who is working as system integrator and operator.[28]

The RAID aerostat system was previously part of the Persistent Surveillance System (PSS) POR within the Army, but it has been

Table 13: RAID Technical Specifications	
Length: 66 ft. **Diameter :** 20.3 ft. **Volume:** 13,300 cu. ft. **Max Payload:** 200 lbs. **Flight ceiling:** Up to 1,000 ft. AGL (lower when pad above 0 ft. MSL) **Duration:** 15 days **Crew:** 12 (for 24 hr. operation) **Payload options:** HD EO/IR with laser range finder, FLIR Star SAFIRE III	 **Figure 20: RAID Showing Payload and Ground Components**[27]

updated and removed from the PSS Capability Production Document (CPD). No systems are in active service at this time. While in service in OEF, RAID was the second program of priority behind mine resistant ambush protection (MRAP) for force protection and detection of IEDs and insurgent activities. The innovative system employed a variety of sensors tethered from an aerostat, later evolving to other platforms, including fixed towers and relocated masts. These systems are widely used for the protection of FOBs in Iraq and Afghanistan.[28]

The RAID program was initiated by JIEDDO in FY03 with Overseas Contingency Operation (OCO) funds provided by PM Integrated Tactical Systems (PM ITS). The Kuwait government has expressed interest in purchasing 12 of these systems, but any foreign government purchases would come after other U.S. agencies had the opportunity to request ownership. No new RAID aerostat systems have been purchased since 2007.

Rapidly Elevated Aerostat Platforms XL B (REAP XL B)

Table 14: REAP XL B Program Overview

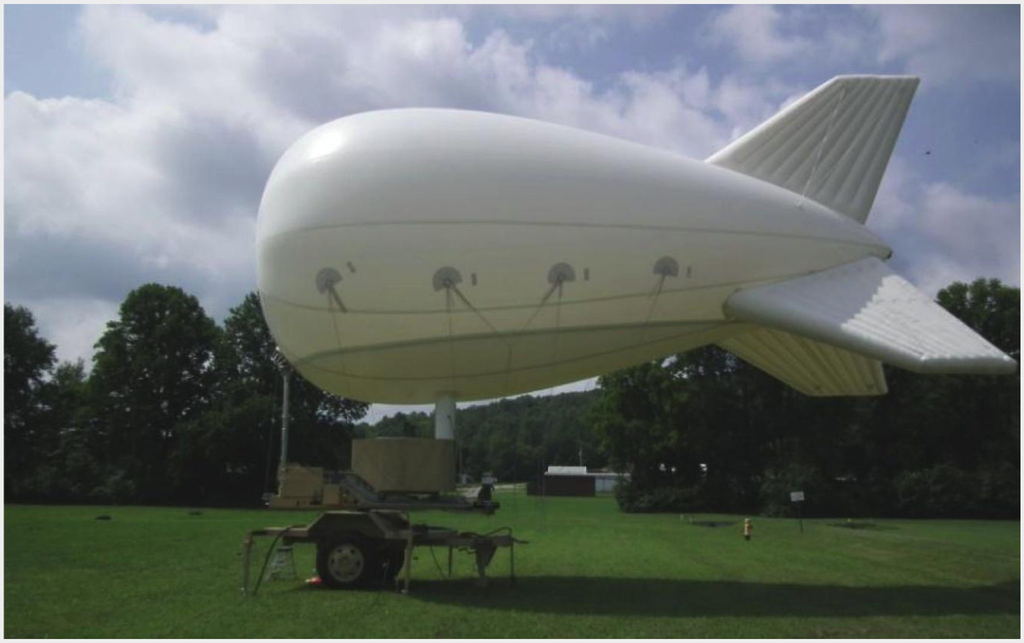
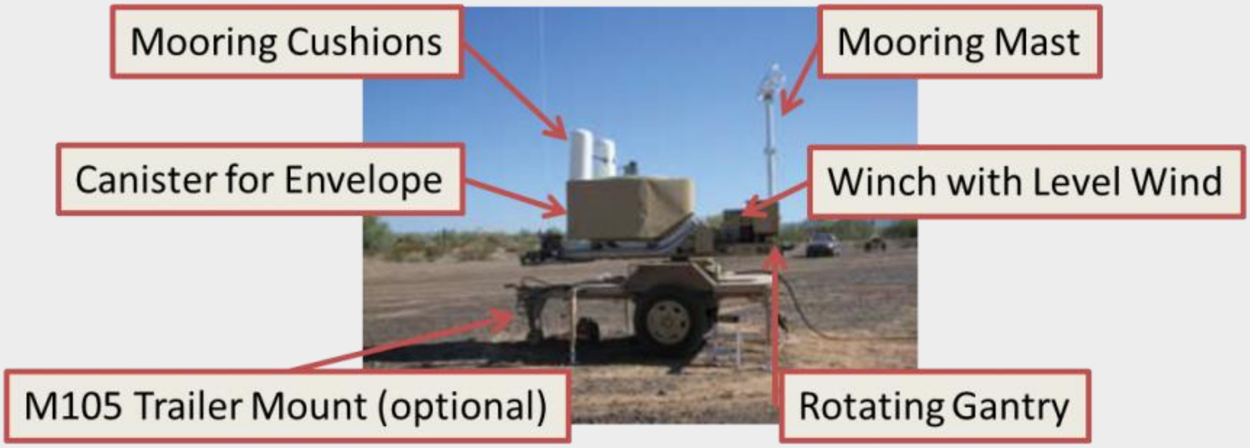


Figure 21: REAP XL B Deployment Sequence[24]

Vehicle Class: Tactical Aerostat	**Primary Contractors:** NEANY Inc., NAVMAR, Information Systems Laboratories Inc.
Mission Set: ISR, Force Protection	**Program Start:** 2010
Organization(s): Army G-2, Army REF, and Navy NSWC PCD	
Technology Readiness Level (TRL): 8–9	

The objective of the REAP XL B program is to provide a small, compact, highly mobile, rapidly deployable/ recoverable ISR system to provide ISR, Force Protection, detecting/identifying targets in day, night, and limited visibility such as haze, smoke, and fog to the battle command team (BCT) and other tactical forces.[29]

REAP XL B is a highly mobile, compact, tactical aerostat system that can move into an area of operation, set up, automatically inflate the aerostat, lift a 120 lb. payload (e.g. COMMS, Signals Intelligence [SIGINT], EO/ IR, short wave infrared [SWIR], FMV, etc.) up to 1,000 ft. AGL in less than 15 minutes and recover in 10 minutes. Currently, U.S. soldiers operate the system after receiving certification training from civilian contractors. Two operators are required to launch REAP, and 3 operators are required to recover the system. Current systems have EO/IR long wave infrared (LWIR)/SWIR payloads, which can view objects out to 10 km. from 1,000 ft. AGL (4,500 ft. operational altitude). REAP XL B measures 39 ft. in length, 16 ft. in diameter

Table 15: REAP XL B Technical Specifications	
 Figure 22: REAP XL B Subsystem Components[30]	
Length: 39 ft.	**Flight ceiling:** 4,500 ft. AGL
Diameter: 16 ft.	**Duration:** 6 days
Volume: 5,000 cu. ft.	**Crew:** 1–3
Max payload: 120 lbs.	**Payload options:** EO/IR, LWIR/SWIR, COMMS

and has an envelope volume of 5,000 cu. ft. It can remain aloft for up to 6 days without a top-off. The sensors are day/night capable and the SWIR enables observation through obscurants (e.g., smoke, dust). The sensors use a wireless transmitter to send data to a laptop computer on the ground. A universal base mounting interface kit allows mounting to virtually any trailer or medium size vehicle, including the mooring system. REAP XL B was also developed for very rapid deployment (approximately 5 minutes) from a tactically mobile two-wheel military trailer towed behind an MRAP or MRAP-All Terrain Vehicle (MATV). Currently, the system is at a TRL of 8–9.[29]

Summary of key technical differentiators are:

- System is compact and thus, highly mobile
- Launched from a canister, requires two operators to launch
- Operated by a Hand Held Controller
- No site preparation required
- Requires only a 30-ft., cleared radius to launch and recover
- Envelope canister easily exchanged for quick turn-around re-launch
- Mooring system integrated into launch unit
- External Ballonet—improved performance with up to 6-day operation with no top off
- Designed for Afghanistan requirements
- One-of-a-kind Flight Termination System

The system design is scalable for varied mission operations through the use of smaller or larger envelope sizes and varied

tether lengths to support different altitude requirements. The data links/COMMS package has an open architecture, with the ability to support a wide range of sensor and communication payload types. This system requires no special site preparation and only a 30-ft. radius clear area for launch/recovery. REAP XL B can be launched and recovered quickly, and the envelope canister can be switched out within minutes if rapid site re-location is needed.[29]

The REAP XL B program was initiated to meet the need for a highly mobile aerostat ISR capability that could provide force protection similar to the larger PGSS and PTDS systems but be relocated every couple of days. The program began as a special project of the Army G-2 in October of 2010 with the purchase of 2 REAP XL B units for rapid development testing and fielding. Two units with multiple spares were purchased by the Army, and 1 unit was purchased for the Navy. At the time of data collection for this report (April 2012), the two Army REAP XL B systems have been deployed in OEF for less than two months, and their performance is still being characterized.[29]

The two systems were procured in order to evaluate a persistent ISR aerostat that was smaller and more mobile than PTDS or PGSS. Typically, the PTDS is rarely moved after installation and the smaller PGSS, while much more mobile, usually remains at the same location. REAP XL B seeks to support operations where relocation occurs every few days as well as those units at combat outposts and other locations that are much too small for PTDS or PGSS. At present, there are requirements for additional REAP XL B systems, though resources have not been committed, pending evaluation of the two deployed trial systems.[29]

The system has been approved by Army Test and Evaluation Command (ATEC) for soldier operation. Systems #1 and #2, with limited spares, are fully operational and deployed to theater with trained soldier operators preparing for an ATEC forward operational assessment (FOA) by July 2012, followed by a Capabilities and Limitations Report (CLR). Additional spares to support the first two systems are in production and are scheduled for completion by the end of the Calendar Year 2012.[29]

REAP XL B was appropriated in FY10 by Army G-2, Army REF, and Navy NSWC PCD. Contractors for the aerostat are NEANY Inc., NAVMAR, and ISL Inc. Full Operation Capability (FOC) was awarded in January 2012. The REF in conjunction with JIEDDO have ordered 5 additional systems.

Small, Tactical, Multi-Payload Aerostat System (STMPAS)

Table 16: STMPAS Program Overview

Vehicle Class: Aerostat

Mission Set: ISR/Force Protection

Organization(s): Army REF

Primary Contractor(s): Carolina Unmanned Vehicles, GTRI

Program Start: 2011

Technology Readiness Level (TRL): 6

Figure 23: STMPAS When Deployed[31]

In June 2011, the Army REF initiated STMPAS to provide an affordable, small-scale, mobile aerostat platform for ISR and force protection support to small operational forces deployed in remote and austere FOBs/COPs that would otherwise lack organic surveillance capabilities. The REF is working on STMPAS in Raleigh, North Carolina, Atlanta, Georgia, and an as-yet-to-be-determined FOB in OEF.[18]

The REF has acquired two STMPAS systems (technical specifications highlighted in Table 17) for testing and FOA. The REF delivered and is testing the systems at the Electronic Proving Ground (EPG), Fort Huachuca, Arizona to obtain a safety confirmation and verify performance capabilities. A CONUS user evaluation is planned at the Maneuver Battle Lab, Fort Benning, Georgia to obtain soldier feedback on the system. Following the user evaluation, the REF will deploy systems in OEF to begin the operational assessment. [18]

At the time of writing, the REF was actively testing the payloads and the aerostat system, with an initial report expected in FY12. Initial test results have demonstrated the expected flight dynamics and durability of the system even under high loads and other adverse conditions. Payload capacity (with no wind) may not be sufficient for high-base altitudes or in extreme heat. Block 0 payload provides a lightweight capability for these conditions. Slightly larger envelope sizes may also be utilized by the system in the future to enhance capacity. [18]

Short-term goals include complete system testing to obtain safety confirmation for aerostat configuration; conduct user evaluation at Fort Benning, Georgia; and deploy two systems to OEF as part of an FOA for light aerostat systems. [18]

The STMPAS system was purchased in FY11 with Army REF funding. The Army REF is currently evaluating STMPAS and Altus and comparing the systems to currently deployed REAP XL B systems.

Table 17: STMPAS Technical Specifications	
Length: 26.87 ft. **Diameter:** 18.2 ft. **Volume:** 2,260 cu. ft. **Max Payload:** 8–18 lbs. **Payload Type:** EO/IR camera, Shot warning, Other **Flight Ceiling:** 1,000 ft. AGL (at up to 5,000 ft. MSL and 82º F) **Duration:** 4 days (without top off) **Crew:** 4	 **Figure 24: STMPAS Subsystem Components**[31]

Tethered Aerostat Radar System (TARS)

Table 18: TARS Program Overview

Vehicle Class: Aerostat

Mission Set: ISR

Organization: Air Force Air Combat Command

Primary Contractor(s): Exelis Systems Corp., TCOM, ILC Dover, Lockheed Martin

Program Start: 1992

Technology Readiness Level (TRL): 9

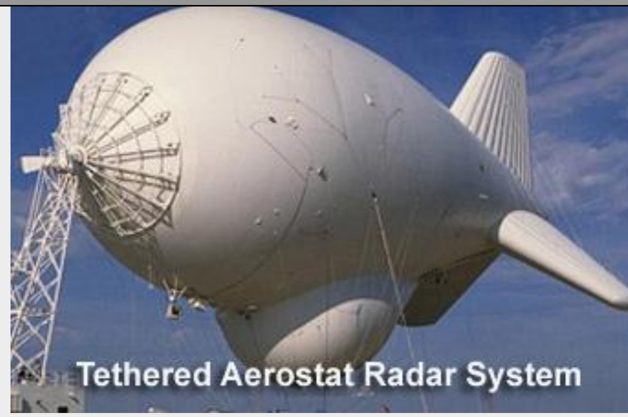


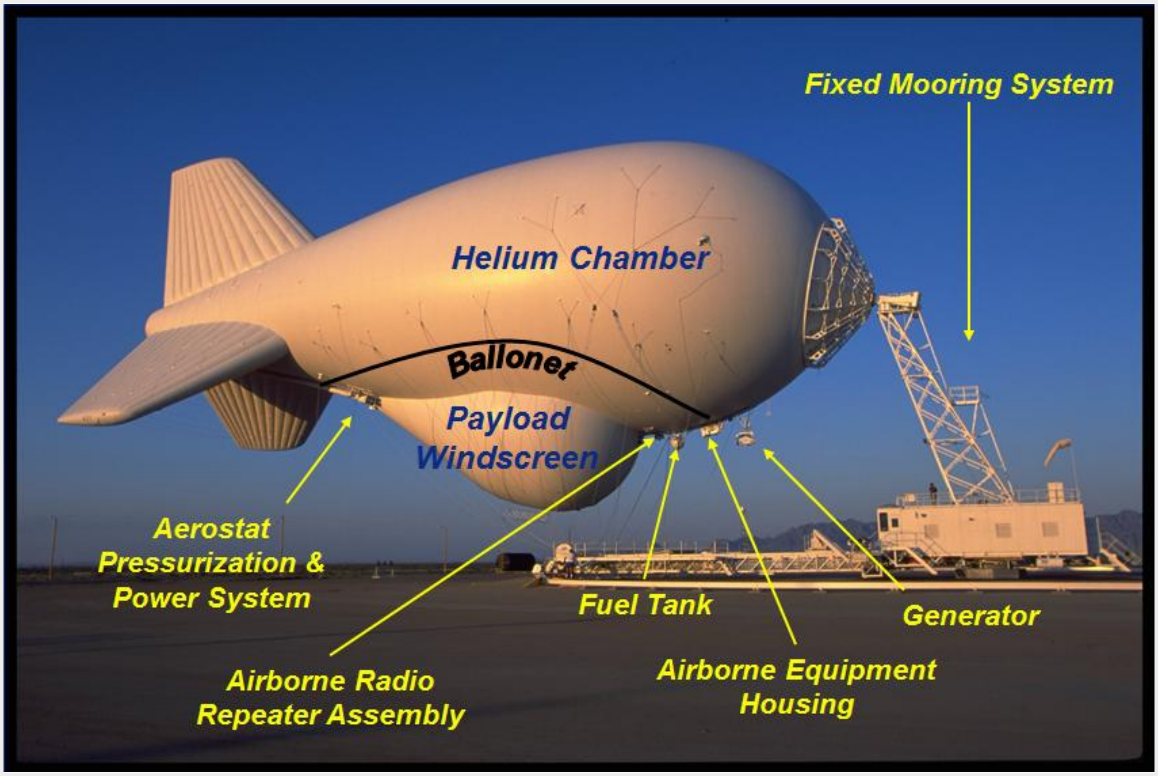
Figure 25: TARS in Moored Configuration[32]

The primary objective of the TARS program is to provide long-range detection and monitoring capability for low-altitude narcotics traffickers approaching the United States. The TARS aerostat system is equipped with Lockheed Martin L-88A or L-88(V)3 L-band radars and has been tested with EO/IR cameras as well. Additional payloads must adhere to current payload weight and power budget limitations. Using an aerostat platform, the system is capable of detecting low-altitude aircraft at the radar’s maximum range by mitigating curvature of the earth and terrain masking limitations.[33]

The TARS program uses two different sizes of aerostats: the 275K and the 420K system (outlined in Table 19). These aerostats can rise up to 15,000 feet above MSL, while tethered by a single NOLARO® constructed, polyester fiber and polyethylene jacketed cable. The normal operating altitude varies by site, but is approximately 10,000 feet MSL. Aerostat power is developed by an on-board, 8.5 kW 400 Hz diesel generator. The aerostat also carries a 100-gallon diesel fuel tank allowing operations up to approximately 6 days before refueling. All systems, including the generator, are controlled via an aerostat telemetry link.[33]

The aerostats detect targets and relay data through a ground control system (GCS) for assessment at a Command, Control, Communications and Intelligence (C3I) center. The L-88A and L-88(V)3 payloads provide a detection range of 200 nautical miles. Winch truck-configured TARS sites require a minimum flight crew of six personnel, fixed mooring system-configured TARS sites require a minimum flight crew of five personnel to operate the systems.[33]

TARS systems were first deployed in 1978. However, TARS formally began as a POR in the mid-1990s when Congress directed the U.S. Coast Guard and Customs Agencies to combine their aerostat capabilities with those of the DoD managed by the Air Force. The 420K aerostat/ LM L-88A radar combination is the standard configuration at seven of the eight TARS sites that monitor the U.S. southern border and Puerto Rico. There is one 275K/LM L-88(V)3 radar combination at the eighth site (Cudjoe Key, Florida). Four of the 420K units (Marfa,

Table 19: TARS Technical Specifications		
 Figure 26: TARS Subsystem Components[32]		
	275K Aerostat	**420K Aerostat**
Manufacturer:	ILC Dover	TCOM, L.P.
Length:	186 ft.	208.5 ft.
Diameter:	62.5 ft.	69.5 ft.
Volume:	275,000 cu. ft.	420,000 cu. ft.
Max Payload:	1,200 lbs.	2,200 lbs.
Payload Type:	L-88A Radar	L-88(V)3 Radar
Duration: 5–7 days **Flight Ceiling:** 25,000 ft., typical = 12,000 ft. MSL **Crew:** minimum 6 for winch truck system or minimum 5 for fixed mooring system		

Texas; Eagle Pass, Texas; Rio Grande, Texas; and Lajas, Puerto Rico) were in operation by mid-1996, and in 1999 Lockheed Martin received a contract to upgrade the remaining stations. The first of these (Deming, New Mexico) came online in October 2000, followed by Yuma, Arizona, in June 2001 and Fort Huachuca, Arizona in September 2001. Lockheed Martin Information and Technology

Services provided operation and maintenance of the aerostats for USAF until 2008.[21] TARS sites are currently operated and maintained under contract with Exelis Systems Corporation. Aerostat envelopes are procured from either ILC Dover or TCOM. Lockheed Martin is the original equipment manufacturer of the L-88A and L-88V(3) radars. [33]

TARS is owned by the Deputy Secretary of Defense for Counter Narcotics and Global Threats. The program is operational and has been in sustainment since the Air Force assumed program management as the Executive Agent in 1992.[33] Air Combat Command executes the program and the government contract management office is located in Newport News, Virginia. The primary agencies using the TARS surveillance data include USNORTHCOM in support of Customs and Border Protection (Air and Marine Operations Center and Caribbean Air and Marine Operations Center) and USSOUTHCOM in support of Joint Interagency Task Force-South. In addition to its Counter-drug/Counter-Narcoterrorism (CD/CNT) mission, TARS surveillance data also supports the North American Aerospace Defense Command (NORAD) air sovereignty mission for the CONUS. [33]

TARS began in 1992 with funding provided by the Air Force, and the DoD is currently planning to transfer the program to the DHS. The TARS budget line item number is 12445F. The program is operating in the sustainment phase, and no new systems or component purchases or upgrades are planned. [33]

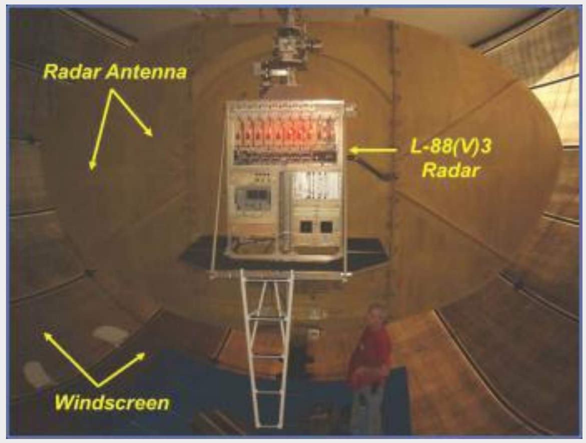


Figure 27: TARS Aerostat[32]

AIRSHIP PROGRAMS

Despite the fact that airships have existed since the 19th century, the technology needed to meet modern requirements of the DoD is largely still under development. The majority of the active DoD efforts are developmental with only one airship currently in operation. Each of the programs detailed in this report is shown in Figure 28.

Figure 28: Airships by Application

Airship ISR missions are often designated as high-altitude (>60,000 ft. MSL) ISR or low-altitude (<20,000 ft. MSL) ISR. This is largely constrained by operating conditions within the Earth's atmosphere. Altitudes between 20,000 ft. and 60,000 ft. are less suitable for airship technology due to the wind conditions at these levels. High-altitude operation is preferred when large fields of view or long-viewing ranges are needed; for example, when looking deep within a country's border while remaining outside its airspace.[4] At present, only technology demonstrators, such as the Army's HiSentinel and HALE-D, have been developed for high-altitude applications. No full-scale deployable platforms have been completed. All high-altitude airship programs to date have been conventional airships; however, technology based on balloons with payload return vehicles have been attempted in the past (Appendix A).

Figure 29 shows specifications for current ISR airships across the DoD. The only fully developed airship currently owned by the DoD, the Navy's MZ-3A, is intended for low-altitude ISR applications and operates as a flying laboratory to develop ISR payloads. The Army's unmanned conventional airship, Skybus, has also been used by the DoD as a flying test bed, but

it is currently disassembled and in storage. The goal of low-altitude airships is to provide longer endurance and ISR persistence over a target area at reduced operational costs compared to HTA vehicles. The Air Force has a low-altitude conventional airship in development (Blue Devil 2), and the Army is developing a low-altitude hybrid airship (LEMV).

Heavy-airlift airships are still early in the development stages. Currently, ASD(R&E) and NASA are developing the Pelican as a sub-scale hybrid airship to demonstrate several key technological advancements required to produce a full-scale heavy-airlift airship. The Pelican program highlights the focus on overcoming technical challenges in new airship technology with respect to the heavy logistics mission. For example, this program is focusing on the development of a variable buoyancy control system, testing new rigid lightweight-composite internal structures, ballast controls, vertical takeoff and landing (VTOL), forward/aft motion controls, and ground handling technologies.

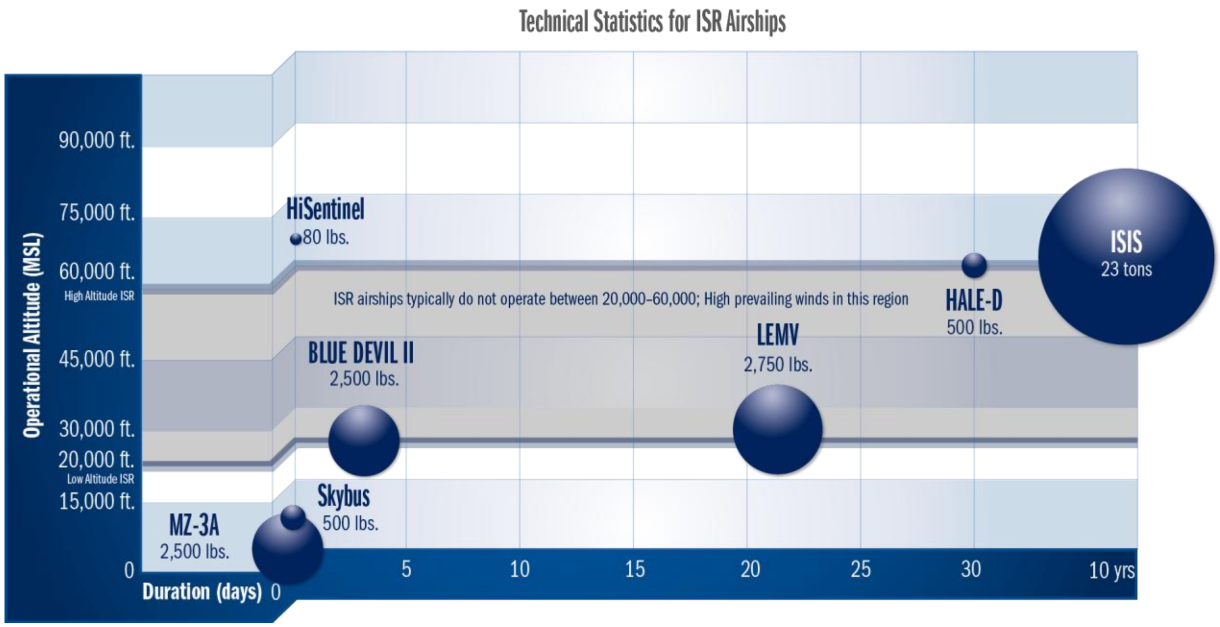
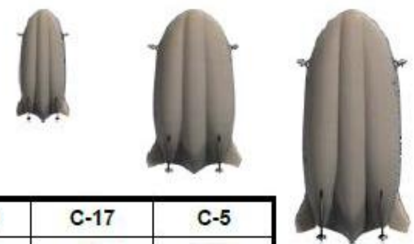
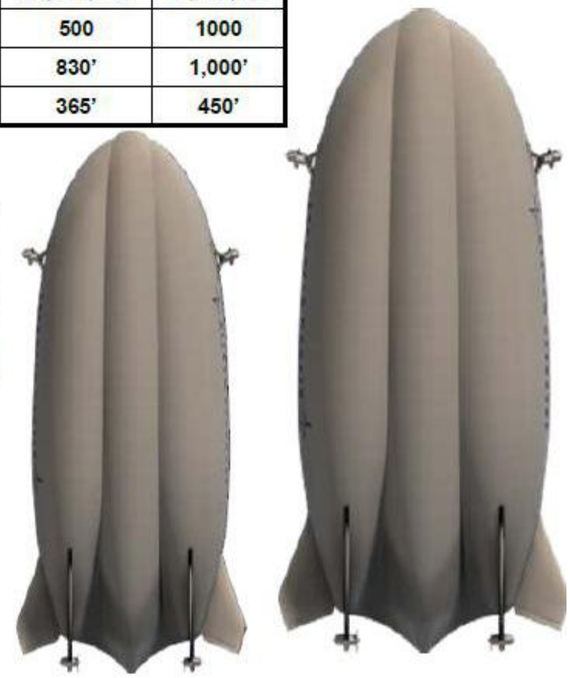


Figure 29: Altitude (MSL), Endurance, and Payload Size Specification Comparison for ISR Airships

Although the current LEMV airship is intended for ISR applications, design studies on a larger heavy-lift version have recently been completed, though this airlift version is not yet under development. Numerous other studies have been conducted to assess the requirements and feasibility of such airships. Estimates have been provided for airships as large as 1,000 ft. in length by 450 ft. wide to carry payloads up to 1,000 tons; however, nothing to this scale is currently in development. Airlift applications can be categorized by the size of the payload and transport distance required primarily for comparison with traditional aircraft and maritime ships. For example, tactical airlift refers to intra-theater operations carrying 20–30 tons (about the payload of a C-130 aircraft). Strategic airlift refers to inter-theater airships carrying 50–100 tons (about the average payload of a C-17 inter-theater airlift aircraft). Very large cargo airships capable of carrying a few hundred tons would offer greater payloads but have lower speed than conventional cargo aircraft and lesser payloads but greater speed than cargo ships[2]

Hull Volume (cu ft)	185,000	1,000,000	3,000,000	35,000,000	67,000,000
Payload (tons)	2	15	50	500	1000
Length	180’	250’	370’	830’	1,000’
Width	75’	150’	185’	365’	450’





	C-130	C-17	C-5
Payload (tons)	15	80	125
Length	97’	174’	247’
Width	132’	165’	222’

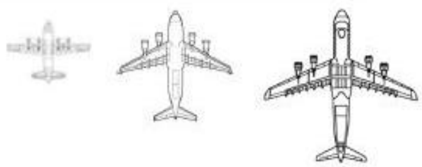


Figure 30: Size Comparison for Hybrid Airships Required for Various Airlift Applications[2]

As discussed in the following pages, several airship programs have invested in subscale/demonstrator technologies to ensure that high priority science and technology challenges and risks are addressed prior to full scale system development. Similarly, several airship systems act as test platforms to validate payload performance prior to full scale integration. These approaches to airship technology development focus attention on the toughest technology problems while ensuring costs are minimized.

Blue Devil 2

Table 20: Blue Devil 2 Program Overview

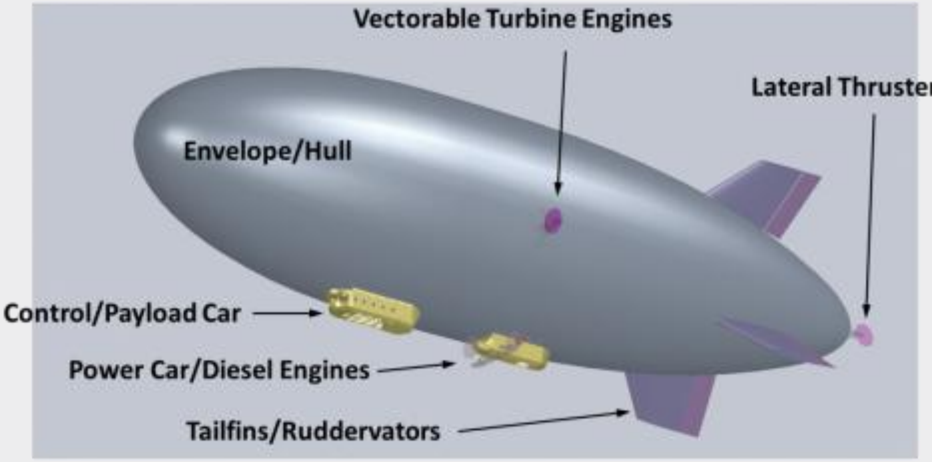


Figure 31: Blue Devil 2 Airship Detail[34]

Vehicle Class: Optionally manned, Conventional Airship	**PM/POC:** Lt. Col. Dale R. White, USAF Big Safari
Mission Set: Low-Altitude ISR	**Program Start:** 2010
Organization(s): USAF, Army, JIEDDO	**Technology Readiness Level (TRL):** 5
Primary Contractor(s): Mav6	**Current Status:** Unfunded

The Blue Devil 2 technology is being developed as a QRC in response to multiple theater requirements covered under JUONS. The system is intended to provide a persistent multi-INT ISR capability, which can provide decision makers with both real-time intelligence and post-mission forensics. The ultimate goal is to provide an airship-based ISR aerial fusion node that integrates multiple distributed and local sensors with on-board processing.[35]

The optionally manned platform is a Mav6 M1400-I, which is developed by airship envelope vendor TCOM as the P1000 model. The airship is 370 ft. long and designed to carry payloads up to 2,500 lbs. (additional specifications shown in Table 21). The ISR payload selected for the system consists of wide area field-of-view (WFOV) and narrow area field-of-view (NFOV) EO and IR sensors for SIGINT cueing, collection, geo-location and target ID, as well as real-time automated tipping and cueing. Communications payloads provide line of sight (LOS) and beyond line of sight (BLOS) communications with tactical users, other ISR assets, and decision makers via common data links (CDLs), laser communications and satellite communications. The diverse communications payload and the vast amount of on-board processing were intended to support the "fusion node" mission set.[35]

Table 21: Blue Devil 2 Technical Specifications

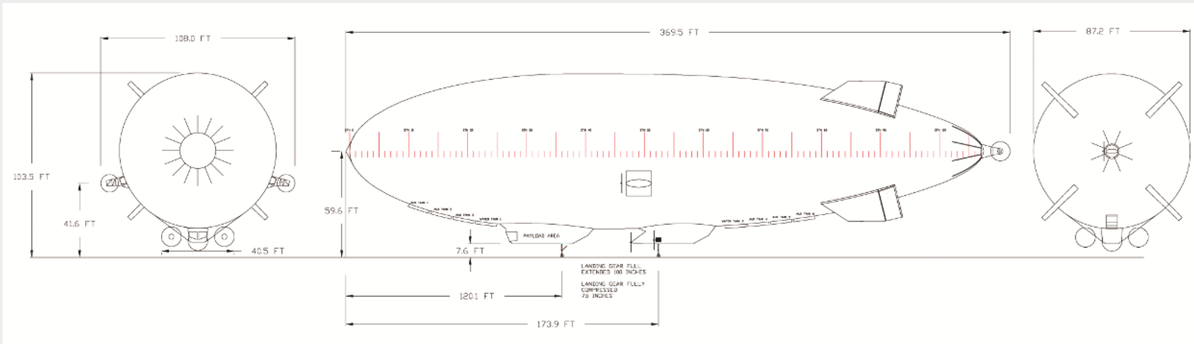


Figure 32: Blue Devil 2 Technical Drawings[34]

Length: 370 ft.	**Flight ceiling:** 20,000 ft.
Diameter: 87.2 ft.	**Duration:** 2–4 days
Volume: 1,400,000 cu. ft.	**Cruise Speed:** 80 kts.
Max Payload: 1,500–2,500 lbs.	**Mass:** 33,000 lbs.
Airship Basic Weight: 42,600 lbs.	**Payload Power:** 30 kW
Payload Type: Wide-area Field of View (WFOV) EO/IR, Narrow-area Field of View (NFOV) EO/IR, COMMS, SIGINT	

The Blue Devil 2 is the second WAS program to bear the name, following on from the manned Blue Devil 1 system that is carried on the fixed-wing Beechcraft King Air 90. The Blue Devil 2 program was launched in October 2010 sponsored by Air Force Headquarters (HAF)/ A2Q (Air Force ISR Innovations Division), which used the Army's Engineering Research and Development Center (ERDC) to award a contract to Mav6 (formerly Ares Systems Group).[35] The program was managed by HAF/A2Q until Secretary of the Air Force (SAF)/AQI (Acquisitions Division) was brought on. Big Safari was then directed to assume management and subsequently awarded a follow-on contract to Mav6 in March of 2011 to continue airship development and integration. The initiative continued to receive support from JIEDDO, which provided a portion of the funding for 2011 fiscal year. [35]

The Blue Devil 2 began FY10 as a QRC effort to integrate commercially available airship technology with primarily Government Furnished Equipment (GFE) sensory payloads, but the program experienced airship envelope and technical setbacks during development including recent failure of the tailfins during testing

Figure 33: Inflated Envelope without Tail Fins[34]

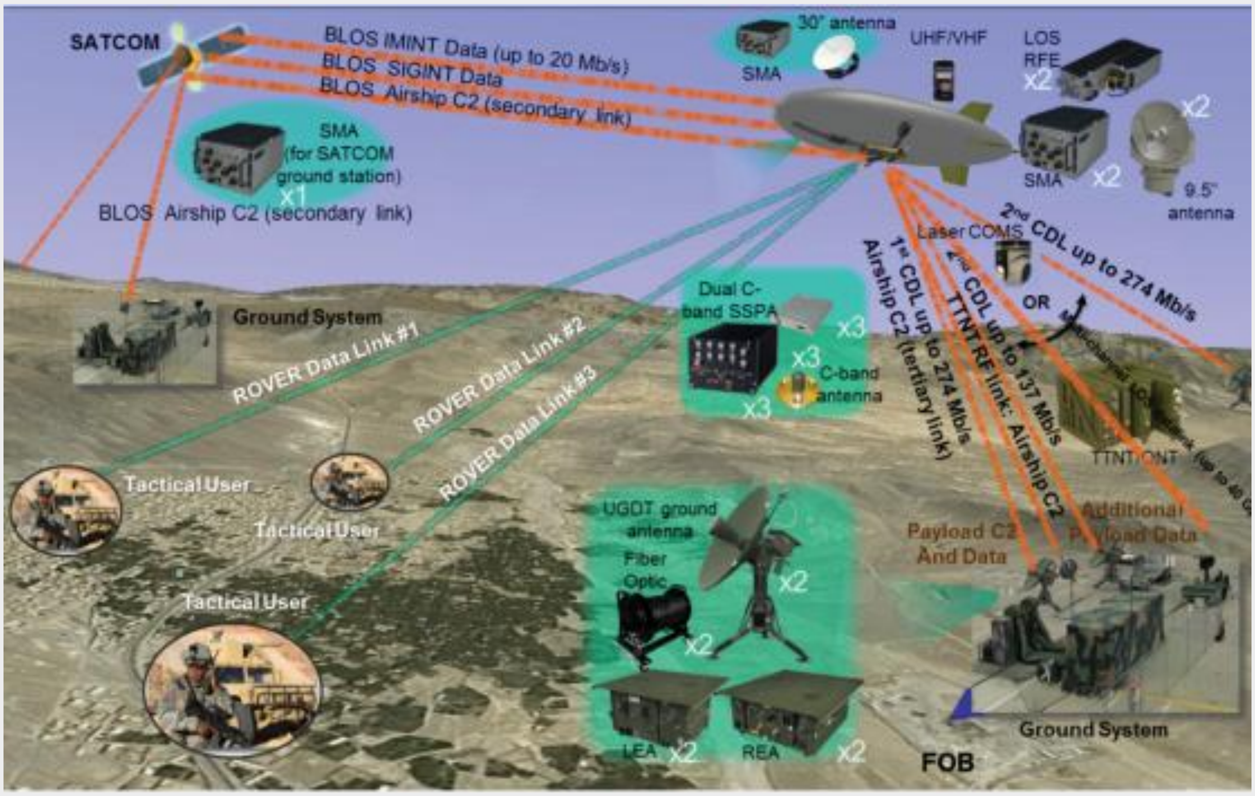


Figure 34: Blue Devil 2 Mission Integration[34]

The original first flight was scheduled for the fall of 2011, but was never completed. Due to the technical and programmatic challenges, in June 2012, the Air Force cancelled the program. [35]

High-Altitude Long Endurance-Demonstrator (HALE-D)

Table 22: HALE-D Program Overview

Figure 35: HALE-D Demonstrator Hovering Outside Hangar[36]

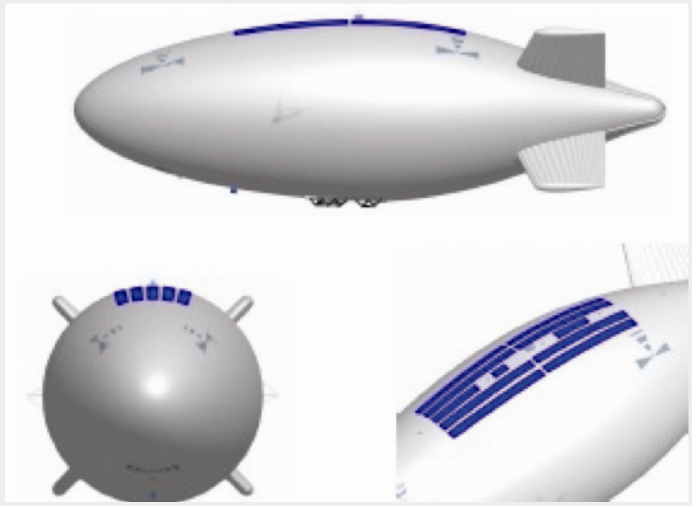
Vehicle Class: Conventional Airship	**PM/POC:** Mr. Rick Judy, Army SMDC
Mission Set: High-Altitude ISR	**Program Start:** 2003
Organization(s): U.S. Army SMDC, MDA	**Technology Readiness Level (TRL):** 6
Primary Contractor(s): Lockheed Martin	**Current Status:** Unfunded

The HALE-D is a sub-scale technology demonstrator built by Lockheed Martin under the management of the Army Space and Missile Defense Command's (SMDC) High- Altitude Airship (HAA) program. The HAA program has held long-term objectives to develop an airship capable of carrying a payload of 2,000 lbs. or more above 65,000 ft. (MSL) for more than 30 days. The HALE-D was a step along this path and served as a demonstrator to test the technologies required for long-endurance at high altitudes.[4]

The original effort to develop an HAA was initiated by the Missile Defense Agency (MDA) in 2003. From the onset, the effort was intended to result in building both a full-sized airship capable of a one-year loiter above 65,000 ft. and an initial prototype that would have an endurance of one month at 60,000 ft. The program was restructured in 2005 to develop the prototype alone, and the effort was transferred to the SMDC in 2008. The resulting HALE-D demonstrator was completed in 2011.[37]

The HALE-D was intended to operate at up to 60,000 ft. MSL for at least 2 weeks (unsuccessful during flight test). The goal of the demonstrator was to test high-altitude technologies such as the thin-film solar arrays for the regenerative power supply, the propulsion system, and the remote piloting data link. The payload used for the demonstration was minimal, weighing less than 50 lbs. and consisting of the following components:[38]

- ITT Hi-Resolution Electro-Optical System providing near-real-time pointing and capture
- Thales Multi-channel, multi-band Airborne Radio (MMAR)

Table 23: HALE-D Technical Specifications	
 Figure 36: Illustration of HALE-D Profiles and Solar Panels[12]	
Length: 232 ft.	**Flight Ceiling:** 60,000 ft.
Diameter: 74.5 ft.	**Duration:** 2–3 weeks
Volume: 580,000 cu. ft.	**Cruise Speed:** 18 kts. (26 kts. max)
Max Payload: 80 lbs.	**Mass:** 3,800 lbs.
Payload Type: ISR	**Payload power available:** 150 W

- L3 Communications Mini-Common Data Link (MCDL).

The first and only flight of the HALE-D was conducted on 27 July 2011. The airship experienced a technical failure three hours into a planned 2-week demonstration at 60,000 ft. After failing to ascend above 32,000 ft. recovery operations were conducted, resulting in a crash landing. The envelope, solar cells, and payload were damaged and destroyed.[4]

HALE-D was initiated in FY03 with funding from the Missile Defense Agency (MDA). The Army SMDC took over funding in FY08. The program was terminated in FY11 and there is no future funding planned.

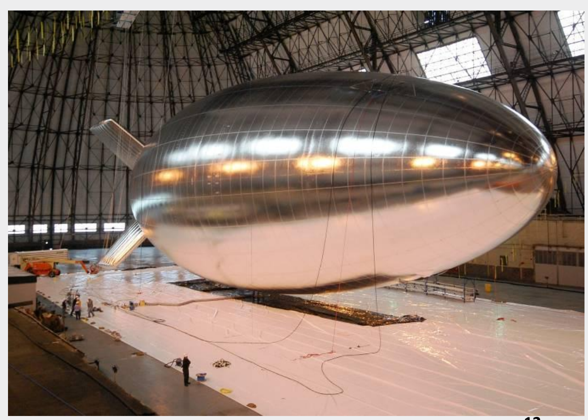


Figure 37: HALE-D Demonstrator in Hangar[12]

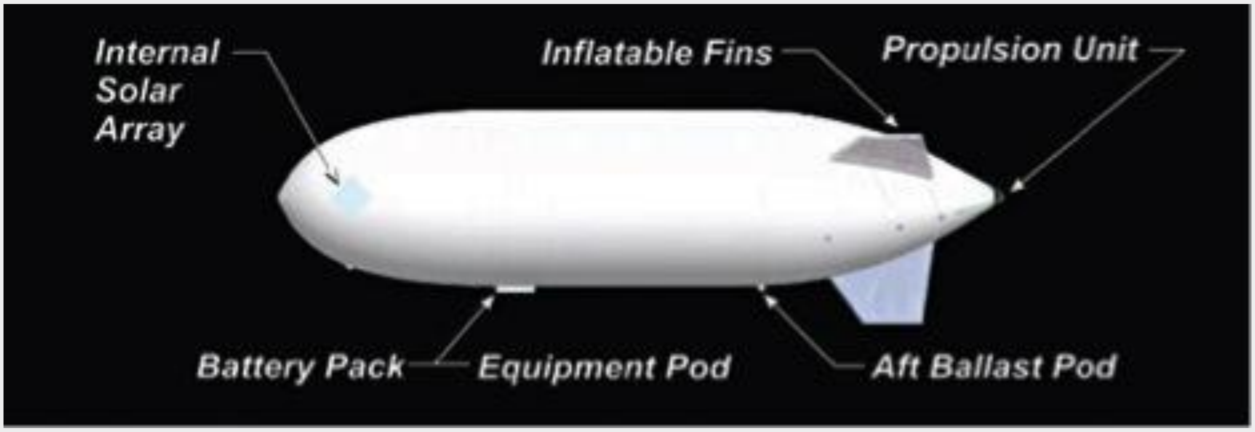
HiSentinel

Table 24: HiSentinel Program Overview	
 Figure 38: HiSentinel in a Football Stadium[40]	
Vehicle Class: Conventional Airship	**PM/POC:** Mr. Rick Judy, Army SMDC
Mission Set: High-Altitude ISR	**Program Start:** 1996
Organization(s): U.S. Army SMDC	**Technology Readiness Level (TRL):** 6
Primary Contractor(s): SwRI and Aerostar International	**Current Status:** Unfunded

The HiSentinel program is one of two HAA programs conducted by the U.S. Army SMDC. HiSentinel is a spiral development project to design a family of high-altitude, long-endurance airships. There have been two generations of autonomous, high-altitude airships developed under this effort dating back to 1996. Three first-generation airships called SOUNDER were built and tested by the contracting team of Southwest Research Institute (SwRI) and Aerostar International. The second generation was designated HiSentinel. The first two iterations of this most recent generation were the HiSentinel 20 and 50. HiSentinel 80 (the latest model) is the third and final airship of this generation, see Table 26.[39]

The goal of the HiSentinel program is to create low-cost and expendable airships that can provide long-duration tactical platforms for military and homeland security application, including surveillance, communications and sensor payloads. The HiSentinel platform launches flaccidly like a balloon, but as the helium expands, it takes on the shape of the airship at altitude (see Figure 40 and Figure 41). It can be launched tactically and is designed to be a single-use, long-endurance platform.[40]

Each model in the HiSentinel series increases in size, mass, and payload mass (20-, 50-, and 80 lbs. respectively) but decreases in achievable altitude. The HiSentinel 20 reached over 74,000 ft. MSL during a test flight in 2005, while the HiSentinel 80 ascended to only 60,000 ft. during its flight in 2010. The payload contents have changed over the model iterations as well, but they maintain an optical/camera system and radio link as the primary components.

Table 25: HiSentinel 80 Technical Specifications	
 Figure 39: HiSentinel 80 Detailed Profile[39]	
Length: 194 ft.	**Flight ceiling:** 60,000 ft.
Diameter: 43 ft.	**Duration:** 24 hours (8 hrs. in actual test)
Volume: 212,800 cu. ft.	**Cruise Speed:** 15–26 kts.
Max Payload: 80 lbs.	**Mass:** 800 lbs.
Payload Type: ISR	**Payload Power Available:** 50 W

The payload package used on the HiSentinel 80 is the same as the payload used on the SMDC's other HAA program (HALE-D), which consists of an ITT hi-resolution electro-optical system, a Thales MMAR prototype, and an L3 Communications MCDL.[37]

A flight test of HiSentinel 80 was conducted in November 2010 to achieve the target altitude, speed and duration, as well as attempt to maintain station-keeping capability. During the test the airship experienced propulsion failure and landed eight hours into a planned 24-hour mission.[4]

HiSentinel was initiated in FY96 with funding from Army SMDC. Funding expired in FY10 and no plans have been made to fund the project in the future.

Table 26: Comparison of HiSentinel Aircraft Generations[12]

	HiSentinel 20	HiSentinel 50	HiSentinel 80
Year of Flight	2005	2008	2010
Altitude	72,000 ft.	66,400 ft.	60,000 ft.
Duration	5 hours	24 hours (3 min. in test flight)	24 hours (8 hrs. in test flight)
Payload	20 lbs.	50 lbs.	80 lbs.

Figure 40: HiSentinel 20 (2005)[12]

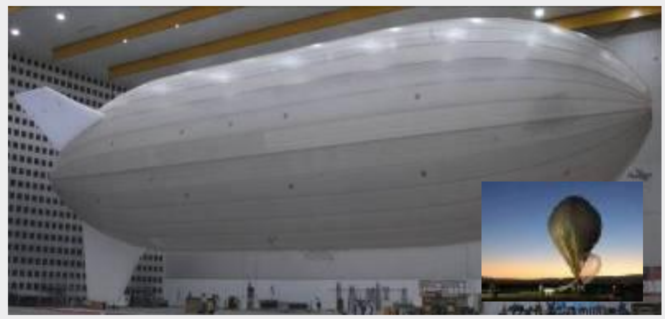


Figure 41: HiSentinel 50 (2008)[12]

Integrated Sensor Is Structure (ISIS)

Table 27: ISIS Program Overview

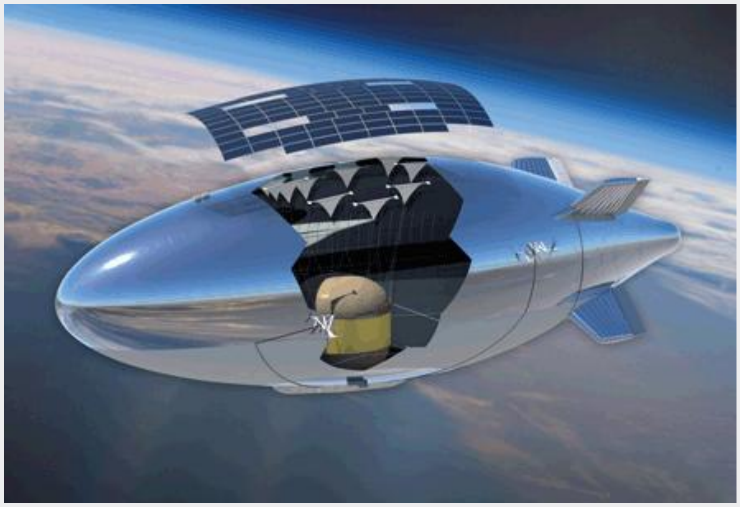


Figure 42: Illustration of ISIS (Expanded View)[41]

Vehicle Class: Conventional Airship	**PM/POC:** Mr. Timothy Clark (DARPA); Mr. Keith Loree (USAF AFRL/RY)
Mission Set: High-Altitude ISR	**Program Start:** 2004
Organization(s): DARPA, Air Force AFRL/RY	**Technology Readiness Level (TRL):** 4
Primary Contractor(s): Lockheed Martin, Raytheon	**Current Status:** Construction of sub-scale demonstrator

ISIS is a fully integrated radar and stratospheric airship providing significant tracking capabilities on air and ground moving targets. Operationally, ISIS systems offer extended radar horizon (higher altitude can see farther), ultra-long-endurance as an objective and a very small forward footprint so they do not have to deploy a huge maintenance footprint.[42]

The ISIS program was started in 2004. The Joint DARPA/ Air Force initiative is developing a sensor of unprecedented proportions, fully integrated into a stratospheric airship to address the nation's need for persistent, WAS, tracking and engagement for hundreds of time-critical air and ground targets in urban and rural environments. The contractors are Lockheed Martin (prime) and Raytheon (sub). Work on the envelope is being conducted in Dover, Delaware. Final integration and launch will be from Akron, Ohio.[42]

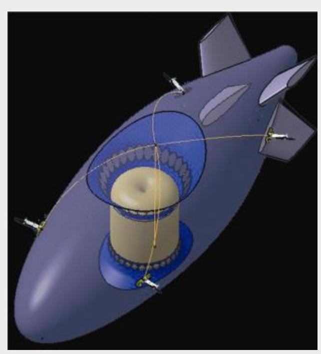


Figure 43: Illustration of ISIS Structure[12]

Table 28: ISIS Technical Specifications

	Demo	Objective
Length	511 ft.	1,000 ft.
Diameter	161 ft.	328 ft.
Volume	5.8M cu. ft.	60M cu. ft.
Mass:	35,000 lbs.	337,000 lbs.
Flight ceiling (MSL)	65,000 ft.	70,000 ft.
Duration	Up to 1 year	10 years
Cruise Speed	49 kts.	116 kts.
Max Payload	2,900 lbs.	38,800 lbs.

Payload Power: 181 kW (10-16 kW to radar) for Demo version

Payload Type: Integrated radar (both versions)

Figure 44: ISIS illustration Showing Technical Concept[43]

Some technical challenges include excess system mass, assembly integration of radar structure into the airship envelope, the X-band beam forming metrology and calibration, regenerative power system reliability, and manufacturing readiness.[42]

Currently, ISIS is in its third phase of development, which started in 2009. This phase includes manufacturing a half-scale demonstration system— a working model of ISIS with a half-scale envelope size and one-tenth-scale radar size. Key accomplishments to date include having conducted a critical design review of the demonstration system, an operational modeling and simulation experiment of the radar system, and development and demonstration of flight dynamic controls in a lab environment. Further, the program has demonstrated large-scale manufacturing prototypes, completed initial integration and performed radar power system critical design reviews. The demonstration launch is planned for February 2014, when DARPA will conduct a 90-day flight program before turning it over to the Air Force while still in the air.[44]

DARPA provided initial funding for ISIS in FY04. In FY10, the Air Force began contributing funds under a joint DARPA/Air Force initiative. In September 2011, the contract was modified to include an “on-orbit” incentive clause tied to technical performance, cost, and schedule.

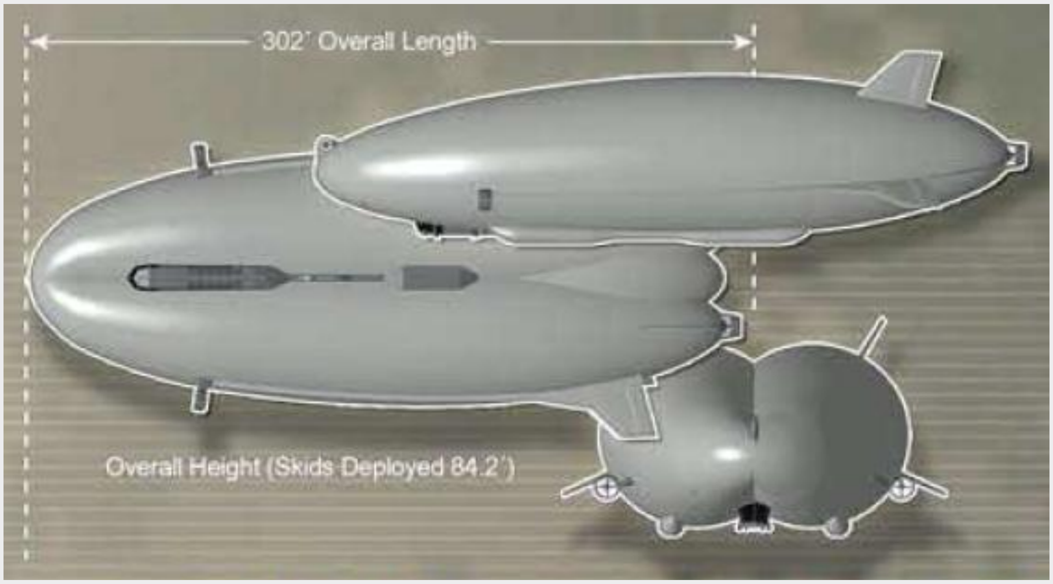
Long Endurance Multi-INT Vehicle (LEMV)

Table 29: LEMV Program Overview	
Vehicle Class: Hybrid Airship **Mission Set:** Low-Altitude ISR **Organization(s):** U.S. Army SMDC/ARSTRAT **Primary Contractor(s):** Northrop Grumman, Hybrid Air Vehicles (UK) **PM/POC:** Mr. Dale Perry, SMDC **Program Start:** 2010 **Technology Readiness Level (TRL):** 6 **Current Status:** Preparing for first flight in mid-June 2012	 **Figure 45: Illustration of LEMV Hybrid Airship[45]**

Figure 46: Photo of LEMV in Hangar during System Integration[46]

The Long Endurance Multi-intelligence Vehicle (LEMV) is an optionally manned, hybrid airship currently under development to provide a long-endurance (up to 21 days unrefueled) capability for persistent ISR missions. The current vehicle is intended for low-altitude (up to 20,000 ft. MSL) ISR missions, but concurrent research has been conducted to modify the vehicle for use in heavy-airlift logistics applications as well. The LEMV is being developed by the Army under the leadership of the SMDC and Army Forces STRATegic Command (ARSTRAT). Northrup Grumman is the primary contractor on the effort with support from UK-based Hybrid Air Vehicles (HAV).[47]

The LEMV is the first hybrid air vehicle intended for operational deployment. It uses a combination of buoyancy, aerodynamic lift (up to 30%), and vectored thrust to take off at greater heaviness and land at greater lightness than possible with conventional airships. Vectored thrust is provided by the LEMV's four Thielert/Centurion heavy-fuel engines, which enable ground maneuvers in addition to supporting takeoff and landing.[47] The result is increased payload and/or greater fuel capacity for long-endurance missions. Flight control can be provided by an onboard pilot, remote pilot control from a GCS, or an autonomous flight control system.[47] The LEMV will be optionally piloted for self-deployment, training and maintenance check flights in the National Airspace System and internationally. The

Table 30: LEMV Technical Specifications	
 Figure 47: LEMV Technical Specifications[46]	
Length: 302 ft.	**Flight Ceiling:** 20,000 ft. MSL
Diameter: 70 ft. x 113 ft. (Cross-section)	**Duration:** Up to 21 days (ISR configuration)
Volume: 1,340,000 cu. ft.	**Cruise Speed:** 25 kts. (loiter), 80 kts. (max)
Max Payload: 2,500 lbs. (ISR), 15,000 lbs. (heavy lift)	**Mass:** Currently Unavailable
Payload Type: 4 HD EO/IR sensors, SIGINT, SAR/GMTI, SINCGARS/EPLRS COMMS relay, ISR aerial network COMMS relay	**Payload Power Available:** Up to 16 kW (sustained)

primary intent is for the airship to operate as a unmanned aircraft system (UAS) in theater deployments.[47]

Development of the LEMV as the first deployable hybrid air vehicle has focused on ISR application as a "multi-intelligence" asset through integration of unmanned control systems and processing/exploitation/ dissemination (PED) ground control stations for controlling multiple payloads and analyzing multiple payload ISR products. Current efforts are focused on developing the airship platform and integration of existing, proven sensor systems. The goal is to provide a long-endurance vehicle capable of persistent ISR missions rather than develop new or improved sensor payloads. The baseline payload suite includes 4 HD (1080p) EO/IR sensors, synthetic aperture radar (SAR)/GMTI and SIGINT packages. The payload bays are modular with common/open interface for rapid integration and deployment of new payloads/payload suites.[47] Additional airship specifications and technical objectives are listed in the Table 30.

Communications relays within the LEMV payload provide ground-to-air-to-ground

SINCGARS/EPLRS and air-to-air/ air-to-ground ISR aerial network communications. Communications and payload control are provided via two ground control stations. The primary GCS handles air vehicle (AV) command and control (C2), payload C2, and payload product PED. The secondary GCS handles AV C2 for remote launch and recovery. AV C2 communications are provided beyond line of sight (BLOS) via satellite communications. LOS operations are conducted using a TCDL.[1]

The LEMV Technology Demonstration Program is authorized per an Other Transaction Authority (OTA) to produce up to three LEMV systems for a Joint Military Utility Assessment (JMUA) for a period not to exceed five years. A JMUA will be conducted following system development and testing, and a Material Development Decision (MDD) is expected 90-180 days after completion of Phase 1 of the JMUA. The Army is the appropriating organization.[47]

The detailed design is complete, and all major aircraft systems, ground control systems, and ground support equipment have been manufactured and delivered. FY12 plans include sub-system integration and checkout of the air vehicle including the following: hull, electrical system, propulsion system, fuel system, flight control system, mission systems, and payloads. Integration and testing will be conducted on the GCS to confirm AV C2, payload C2, and payload product PED, with information assurance certification as well. The near-term goal is to complete integration and conduct system-level testing demonstrating manned and unmanned flight operations. System demonstrations and first flight are currently planned for the summer of 2012. Pre-deployment demonstrations will be conducted to assess military capability and limitations. Longer term plans include a self-deployment from a CONUS location to a Joint Military Utility Assessment (JMUA) location to be conducted in FY13 with the ultimate goal of providing continued operational support to combatant forces.[47]

The Army provided initial funding for LEMV in FY10. Current plans are to fund the program through a JMUA to be conducted in FY13.

MZ-3A

Table 31: MZ-3A Program Overview	
Vehicle Class: Conventional Airship **Mission Set:** Low-Altitude ISR (Flying Laboratory) **Organization(s):** Navy NAVAIR **Primary Contractor(s):** Integrated Systems Solutions, Inc. **PM/POC:** Mr. Bert Race, NAVAIR **Program Start:** 2005 **Technology Readiness Level (TRL):** 9 **Current Status:** Utilized for Army research	 Figure 48: MZ-3A in Hangar[48]

Acquired in 2005 and designated MZ-3A, the Navy's airship is a commercial derivative A-170 advertising blimp built by American Blimp Corporation. It is used as an airborne flying laboratory to service Joint Science and Technology efforts involving integration of multiple and/or unusual configuration mission systems requiring airborne evaluation in a highly stable environment. The MZ-3A is extremely fuel efficient and has a flexible payload configuration, which allows for rapid systems integration and flight clearance. The MZ-3A is suitable for operation as a flying laboratory because it provides a stable and persistent field of view, low vibration, and a large volume per unit payload accommodation.[49]

Figure 49: MZ-3A Docked on Mooring Truck[50]

The MZ-3A is a Government-owned, contractor-operated airship maintained by Integrated Systems Solutions, Inc. The MZ-3A is operated from many locations throughout the year depending on customer requirements.[49]

The MZ-3A has been used in a variety of missions and exercises. For example, it was used in the Gulf of Mexico to monitor the Deepwater Horizon oil spill. It is currently serving as a sensor test platform for the Army with a primary function of operating as a surrogate sensor platform for quick reaction capabilities under development.[49]

Navy provided initial funding for MZ-3A in FY05. The MZ-3A has no sustained budget. Current plans are to operate the system as a customer funded platform and as user demand requires. Operational sustainment requires fiscal support from current and future customers. Should the Navy ever encounter circumstances where there is no immediate need for its services, the airship will be placed in a low-cost deflated state of preservation that will allow future reactivation.[49]

Table 32: MZ-3A Technical Specifications

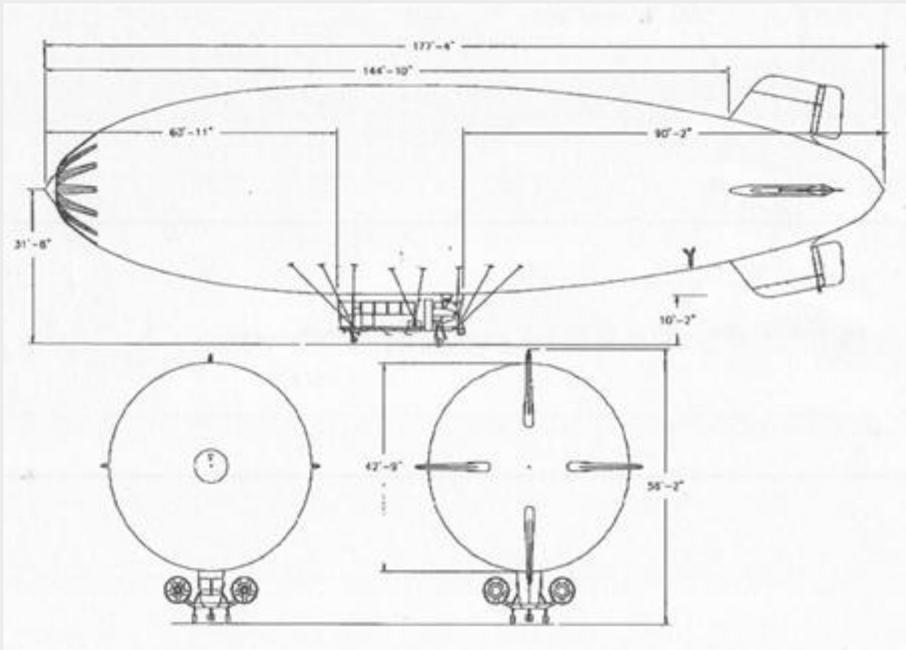


Figure 50: MZ-3A Specifications[49]

Length: 178 ft.	**Flight Ceiling:** 9,500 ft.
Diameter: 43 ft.	**Duration:** >10 hours (flight), >24 hours (max endurance)
Volume: 170,000 cu. ft.	**Cruise Speed:** 35 kts. (45 kts. max)
Max Payload: 2,500 lbs.	**Mass:** 6,300 lbs.
Payload type: Experimental, ISR (client driven)	**Payload Power:** 9.5 kW (28VDC); 2.5 kW (120VAC)

Pelican

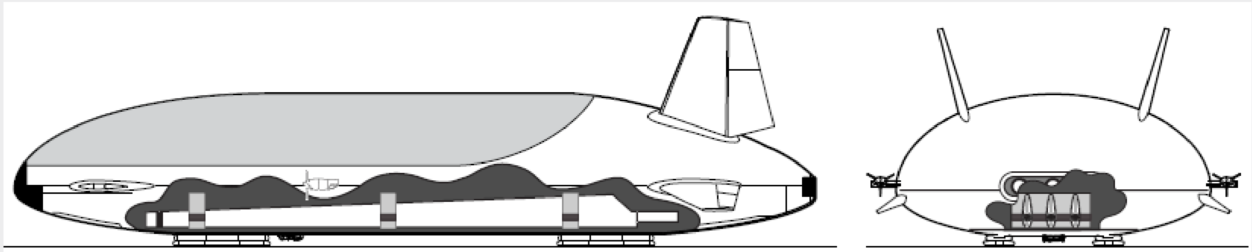
Table 33: Pelican Program Overview

Figure 51: Pelican Illustration[12]

Vehicle Class: Hybrid Airship	**Program Start:** 2008
Mission Set: Heavy-Lift Logistics	**Technology Readiness Level (TRL):** 5
Organization(s): ASD(R&E), NASA Ames	**Current Status:** Airship integration in progress with plans to conduct hangar test in late 2012
Primary Contractor(s): Aeros Corp.	**PM/POC:** Paul Espinosa (NASA Ames)

Pelican is the consolidation of three past efforts, and its objective is to demonstrate that the technology of scalable VTOL has matured and these technological advances can be combined to create a hybrid airship suitable for heavy-lift operations. The goal of the program is to mitigate long-term development risks by demonstrating the fundamental characteristics of the RAVB vehicle. The key technologies to be demonstrated include: a buoyancy control system enabling ballast-independent operations; a rigid, lightweight-composite external structure; a responsive low-speed/hover control system; and ground handling capabilities to enable operations without a ground handling crew.[51]

The Pelican hybrid airship builds on three prior DARPA efforts: Walrus, Control of Static Heaviness (COSH), and Buoyancy Assisted Lift Air Vehicle (BAAV). Walrus was an effort conducted by DARPA/Tactical Technology Office to define an objective vehicle concept and provide the technical data to evaluate the military utility of a global reach vehicle. This effort culminated in a Technology Development and Assessment Plan submitted in 2006. The COSH project, completed in July 2008, provided a technology demonstration of a system that changes the density of helium with a flight-qualified compression system. This effort proved the concept of the helium pressurization envelopes (HPEs) that are

Table 34: Pelican Technical Specifications	
 Figure 52: Pelican Envelope Profiles[52]	
Length: 256 ft.	**Flight Ceiling:** Hangar Demo Only
Diameter: 96 ft. (max)	**Duration:** Hangar Demo Only
Volume: 732,110 cu. ft.	**Cruise Speed:** Hangar Demo Only
Max Payload: 44,000 lbs.	**Max Speed:** Hangar Demo Only
Payload Type: Airlift/logistics cargo	**Payload Power Available:** 18–19 kW
Range: Hangar Demo Only	**Mass:** 41,117 lbs.

utilized in the Pelican airship. The BAAV program, which was completed in 2009, conducted hangar tests to prove a composite rigid structure application to a LTA vehicle.[51]

Project Pelican is an effort led by the ASD(R&E)-RRTO and managed in conjunction with the NASA Ames Research Center. The effort seeks to combine a variety of previously tested technologies into a single, non-deployable technology demonstrator. Contractor Aeros Corporation leads the development and integration work. Aeros was awarded the contract for the effort in May of 2009. ASD(R&E)-RRTO has responsibility for the overall project requirements and provides funding within DoD and Congressional guidance. NASA Ames Research Center is responsible for administering the contract and providing technical oversight. Additional program and technical support is provided by Air Force/AFRL.[51]

Pelican is currently in the subsystem verification and vehicle integration phase. Preparations are also being made for the hangar demonstration, which is currently scheduled for late 2012. The hangar demonstration has several objectives. The first goal is to demonstrate the effectiveness of the variable buoyancy control COSH system that changes the density of the vehicle's helium to affect control over the airship's buoyancy. The second goal is to prove the rigid lightweight-composite external structure of the RAVB aircraft maintains envelope integrity without relying on differential gas pressure.

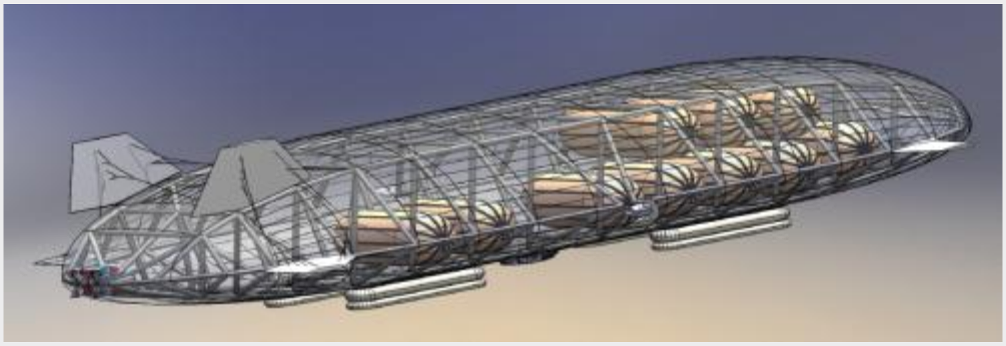


Figure 53: Illustration Showing Lightweight Rigid Structure and HPE[53]

Another goal is to demonstrate the airship does not need external ballasts to compensate for offloading payloads. Additional tests will demonstrate VTOL, forward/aft motion, and ground handling. The contract is set to end after the hangar demonstration.[51]

Pelican was initiated in FY08 with funding from OSD. This proof of concept project was planned for a five-year period from late FY08 to FY13. Current plans are to complete a hanger demonstration, with no intent to provide additional funding beyond that point.[51]

Skybus

Table 35: Skybus Program Overview	
Vehicle Class: Conventional Airship **Mission Set:** Low-Altitude ISR (Flying Laboratory) **Organization(s):** Army, OSD, Navy **Primary Contractor(s):** SAIC **PM/POC:** Mr. Kevin Johnson, Army G-2 **Program Start:** 2007 **Technology Readiness Level (TRL):** 7 **Current Status:** Currently being reassembled for demonstration	 **Figure 54: Skybus in Flight**[54]

The Skybus 80K is an experimental, remotely piloted, unmanned airship used as a payload test platform for the Army. The current Skybus 80K platform, developed by SAIC, originated from the Skybus 30K and replaced the Small Aerostat/Airship Surveillance System (SASS) Lite airship program. The Skybus is in storage due to a lack of funding in FY11, but the Army G-2 and NAVAIR are funding the reassembly for an operational demonstration.[14]

The Skybus uses a multi-payload gondola for payload testing that is capable of supporting a variety of payloads weighing up to 500 lbs. The platform is equipped with:[54]

- FMV Turrets—MX-14, MX-15i/HD, MX20, MX-10i
- Star Safire III—MX-12i
- COMMS Relays—EPLRS, SINCGARS
- Wideband Networks—AGIG, NG

Payloads tested on Skybus have been developed by a number of organizations, including industry and government labs—Air Force Research Lab (AFRL), ARL, and the Naval Research Lab (NRL). The platform has been utilized to test the following payloads: [54]

- M-TCDL or small UAS for Rover/OSRVT broadcast
- Boomerang, UTAMS gunfire detection
- IP-based plug and play payloads
- Airborne Weapons Surveillance System (AWSS)
- Aerostat Mounted UTAMS (AMUS)
- SIGINT payloads

The Skybus operates out of a fully integrated ground control station. The ground crew required to operate the Skybus varies from 6–12 people depending on weather conditions.[14]

The Skybus program began in 2003 as the SASS Lite program. The Army transferred the program to SAIC in 2006 after the original contractor experienced technical difficulties. The original airship had problems with its design, which ultimately led to a crash while under operation by the original contractor.[14]

Table 36: Skybus Technical Specifications

Figure 55: Payload Mounted On Airship; AWSS (left) and Gondola With MX-14 Turret (right)[54]

Length: 136 ft.	**Flight Ceiling:** 10,000 ft. (MSL)
Diameter: 48 ft.	**Duration:** 19 hours
Volume: 80,600 cu. ft.	**Cruise Speed**: 45 kts.
Max Payload: 500 lbs.	**Mass:** Currently Unavailable
Payload Type: ISR, COMMS	**Payload Power:** 15.6 kW

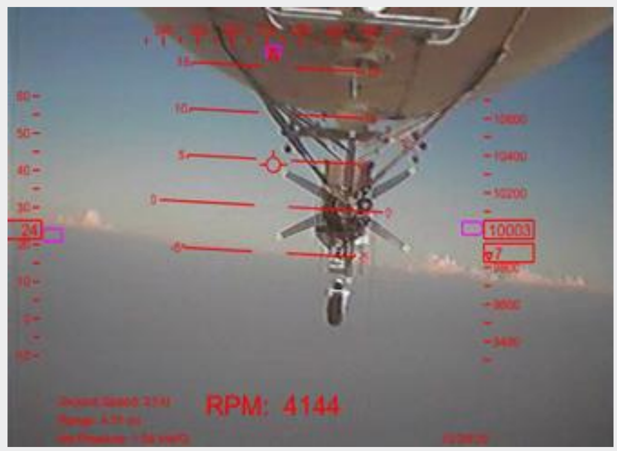


Figure 56: View From Skybus Payload[54]

After assuming control of the program, SAIC made modifications to address technical issues with the SASS Lite version and redesigned the fins and flight control systems. SAIC fabricated the new components and completed integration on the newly designated SKYBUS 30K. SAIC then worked with the Federal Aviation Administration (FAA) to gain experimental certification, which was granted on 22 May 2007. The first flight of the SKYBUS 30K was conducted on 8 June 2007, and a total of 51 flights were conducted accumulating approximately 80 hours of flight time.[14]

From the 30K experience and understanding the deficiencies of the SASS Lite envelope, SAIC proposed and outlined the totally new Skybus 80K in 2007, which was designed to meet OSD specified requirements to fly 500 lbs. of useful payload to 10,000 ft. altitude (MSL) for a 24-hour mission with 25 kt. winds aloft. OSD provided initial funding, and NAVAIR took the program management role. The 80K contract was awarded on 14 March 2008, with the Federal Aviation Administration (FAA) certification process started on 30 May 2008. The airship was completed by the end of July 2008.

Figure 57: Skybus Shown in Storage[54]

A formal FAA review occurred on 14 August 2008, after which funds were exhausted. The 80K airship then sat in the hangar, and the program stalled at the end of September 2008.[14]

In 2009, Skybus 80K transitioned from the Navy to the Army. Army G-2, with earmarked funding from the House Armed Services Committee (HASC), was asked to work with the experimental airship. Army G-2 requested ARL to run the program. On 15 April 2009, the FAA renewed the experimental certification, and flight testing resumed by September 2009. Flight testing continued until July 2010, with the system completing 31 flights and accumulating 80 hours of flight time. The program confirmed the ability of the 80K to take 500 lbs. of payload to 10,000 ft. (MSL) with up to 24 hours of endurance.[14]

In August 2010, the 80K system was packed and shipped from the Loring Test Center in Maine to the Yuma Proving Grounds, and efforts have been on-going to get it out of storage and into operation as an asset. An unfunded request (UFR) to continue experimentation was denied in FY11, so the airship remained in storage.[14]

Skybus was initiated in FY07 with funding from OSD. In FY09 the Army obtained ownership and began funding the program. Skybus 80K UAS is fully funded for FY12 by Army G-2 funds with NAVAIR acting as the distribution organization and funding is planned through FY14. The FY12 budget includes complete support for inflation, operation, maintenance, infrastructure and personnel.

APPENDICES

Appendix A- Balloons

Introduction

Balloons are not considered within the scope of this report; however, they will be addressed here briefly as they utilize similar technology and often provide precursor experimentation in the development of other LTA vehicles. The AFRL maintains the only active balloon program within the DoD. There have been recent attempts to employ balloons with payload return vehicles to operate similarly to high-altitude airships, but these efforts are no longer funded within the DoD.

Technology Overview

Balloons are typically defined as free-floating envelopes capable of carrying payloads to high altitudes. They range in size from small weather balloons that may be launched by hand to very large balloons capable of carrying payloads of up to 8,000 lbs. Free floating envelopes can carry payloads to stratospheric altitudes (up to 150,000 ft. MSL) or higher.[55] Without propulsion the balloon's direction and speed are subject to the atmosphere's prevailing winds, and balloons are unable to maintain position over a given area. A technique of releasing multiple balloons at strategic intervals is often employed for applications such as remote communications relays that require persistence over an area.[55]

A much less common type of balloon is a steerable balloon, which includes a mechanism for station-keeping to enable persistence.[56] The propulsion is typically provided by the addition of a payload return vehicle (PRV), which allows the balloon to operate similarly to a conventional airship.[57,58] These LTA vehicles differ from conventional airships in that the balloon (envelope section) is considered disposable and is discarded at the end of each flight. The payload is integrated into a PRV that detaches from the envelope near the end of the flight and is guided back to a dedicated retrieval sight. The PRV is operated as a UAS glider on its return flight.

Balloons capable of operating in near space (upper stratosphere) come in two types: zero-pressure and super-pressure.[56] Both types typically use helium gas for lift and are made of a variety of common plastic materials such as latex or polyethylene.[59] The zero-pressure balloons, such as weather and recreational balloons, have openings so the pressure remains the same inside and outside the balloon; thus as the balloon rises, the volume expands to maintain a zero-pressure differential. These balloons will rise until they burst, find a buoyancy point, or lose lift via gas diffusion through the permeable material. If a polyethylene balloon achieves neutral buoyancy, it can stay up for a month or more.[56] The super-pressure balloons are completely sealed and maintain higher pressure inside the balloon in order to maintain altitude during night and day temperature changes. The balloons are typically launched partially filled with helium and as the balloon rises the helium expands to fill the balloon as it reaches the desired float altitude.[59]

Scientific Balloons

The USAF operates the only active DoD balloon research program from Kirtland Air Force Base (AFB) in New Mexico. The Air Force's High-Altitude Balloon Program is conducted by the AFRL Space Vehicles Directorate, Integrated Experiments and Evaluation Division. The

program serves the DoD as well as other government agencies and DoD-sponsored university and industry projects.[60]

The AFRL balloon program uses a wide range of scientific helium balloons to provide stratospheric access for research, development, test and evaluation purposes. The program operates primarily to provide a stratospheric test bed and provides the only DoD-sponsored launch, flight, and recovery service.[61] The majority of testing conducted by the AFRL balloon program is limited to precursor experimentation for technology that will ultimately be applied to a variety of stratospheric ISR or communications applications.[61] High-altitude balloons provide an effective, low-cost platform for proof-of-concept or risk reduction experiments related to space environment qualification; meteorological measurements; optical, infrared, ultraviolet, and radar surveillance; radio and laser communications; and target simulation.[60,61]

Figure 58: Example of a High-Altitude Balloon Launch. Balloon Shown on Right with Connected Payload Suspended by a Crane on the left[61]

The AFRL balloon program has a wide range of balloon types and sizes available to accommodate the variety of applications they support. The balloons and rigging are fairly standard and the same technology is used across multiple applications. Rigging includes the flight control and termination devices, such as the ballast hoppers and valves. Ballast hoppers filled with hundreds of pounds of fine glass beads that resemble sand can be emptied to increase altitude and valves can be used to release helium and lower the balloon. Altitude control allows the test controllers to place the balloon in the desired wind currents or dodge restricted air space as needed. The rigging's termination devices include the mechanisms that attach the payload gondola to the balloon. Pyrotechnics are used to separate the balloon from the gondola so the payload can glide back to earth via parachute. The gondola is frequently custom built for the needs of the payload under test, and the AFRL has all the facilities required for the custom fabrication.[61]

Tactical Balloons

Free-floating balloons have been adapted for tactical use in limited situations. The primary application has been to provide widespread coverage for tactical ground-to-ground communications in remote or isolated areas. After Combat SkySat demonstrations in 2005, the USAF Space and Missile System Center funded Near Space Communications Systems (NSCS) to be built by Space Data Corporation. Combat SkySat and the eventual NSCS were based on technology implemented in Space Data Corporation's StarFighter Integrated Repeater. The technology consists of a small weather balloon with some altitude control to allow steering by winds and one or more small communications payloads. The communication payloads operate as repeaters compatible with standard Military ultra-high frequency (UHF) radios. The payload

could be separated from the balloon and returned to the ground via a parachute and global positioning system (GPS) tracking unit for recovering the payload if necessary.[63]

Steerable Balloon Development

A few limited ventures by the DoD have attempted to develop steerable balloons. The primary objective of these steerable balloon efforts has been to develop a balloon with station-keeping ability that can provide capabilities similar to those desired from conventional high-altitude airships. None of the DoD programs have successfully fielded a steerable balloon under DoD funding. The Air Force's Near Space Maneuvering Vehicle (NSMV) effort was ended in 2005, after a crash during a flight demonstration. The High Altitude Shuttle System has been assumed by NASA, but is focused primarily on the PRV. The StarLight program sponsored by NAVAIR expended its funding without completing a demonstrator in October of 2011.

Near-Space Maneuvering Vehicle (NSMV)

The NSMV was a concept developed by JP Aerospace for the Air Force Space Battle Lab (SBL). The program utilized technology based on JP Aerospace's Ascender vehicle. The vehicle consists of two large cylindrical balloons connected on one end to form a 175 ft. V-shaped vehicle (Figure 59). The payload and propulsion system were suspended between the two cylinders.[56] The program objective was to provide a communications relay platform at altitudes above 65,000 feet. The program encountered technical problems with the propulsion system, which caused redesigns and failed launches. The Air Force decided to end the program in 2005.[63]

Figure 59: NSMV Balloon Floating in Hangar[65]

High Altitude Shuttle System (HASS)

HASS (Figure 60) was developed by Near Space Corporation (NSC) (also operates as GSSL, Inc.) of Oregon. The effort was funded in the 2009 fiscal year by the Army Missile Defense Systems and Integration and supported by the Army SMDC Space Battle Lab.[66] Funding for development by the Army ended in 2010, but NSC is continuing development in conjunction with NASA for commercial applications. The system combines NSC's Tactical Balloon Launch System (TBLS) with a high-altitude unmanned shuttle that serves as the PRV.[67] The TBLS allows the system to be launched with only a few persons in winds up to 30 kts. Flight altitudes and trajectories can be controlled with modifications on the ground prior to deployment

Figure 60: High-Altitude Shuttle System[67]

and use of ballasts.[57] The balloon is designed to carry payloads up to 100,000 ft.[67] The PRV (Figure 61) has a standard payload bay made of non-conductive and RF transparent materials that allow a variety of payload systems weighing up to 22 lbs. to be semi-autonomously returned to a pre-designated location. The flight termination, flight control, avionics suite, and ballasts systems are all integrated into the PRV shuttle.[57]

Figure 61: HASS PRV[67]

StarLight

The StarLight system (Figure 62) is based on the same HASS concept of combining a balloon with a PRV. StarLight differs in that it is intended to stay on station for longer durations (up to 3 or 4 months) and operate as a high-altitude airship, while HASS remains in the air for only 24 hours and is focused on development and application of the PRV. StarLight is developed by Global Near Space Services (GNSS) and Byer Aerospace. GNSS received funding from the Navy's Naval Air Warfare Center under the Long Endurance, Alternative Energy Stratospheric Airship Program to design and engineer a 40% sub-scale version of the system, but the contract completed in October 2011 without a complete technology demonstrator. The envelope only made it to preliminary design review. A 40% sub-scale demonstrator of the Stratospheric Return Vehicle (SRV) was half complete. The effort is currently unfunded.[68, 69]

Figure 62: Two-stage StarLight System[69]

The StarLight objective was to develop a system with a flight ceiling of 85,000 ft., with an operational payload of up to 500 lbs. The altitudes that can be achieved vary depending on the size of the payload. For example, the system is designed to carry up to 4,000 lbs. when the altitude is lowered to 65,000 ft. The initial goal of the subscale demonstrator under development for NAVAIR was to reach 65,000 ft. with a small payload.[68]

The StarLight system has a unique two-stage patented design. The airship is at first a flaccid balloon when it takes off. Then, once at a proper altitude, it becomes an airship with a hanging SRV (Figure 63) hanging underneath the envelope. The SRV provides flight control for the balloon to operate as an airship, in addition to operating as a payload recovery vehicle. The balloon system does not require a hangar and can launch out of an ISO container or from a ship, which increases its flexibility. The envelope is disposable and replaced every three months.[58]

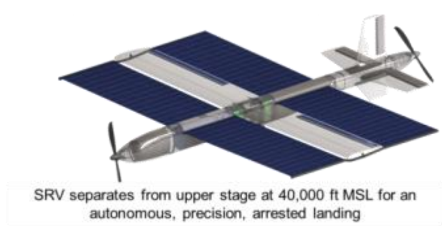


Figure 63: StarLight Stratospheric Recovery Vehicle[69]

Appendix B – Glossary of Terms

A

Aerostat: A tethered, unmanned airship.

Airlift: The transportation of people, equipment, or other cargo by air.

Airship: An aircraft that obtains buoyant lift from a contained volume of helium or other gas that is less dense than the surrounding air.

C

Conventional Aircraft: An aircraft that does not rely on buoyant lift to achieve flight. This refers to heavier-than-air (HTA) aircraft such as fixed-wing aircraft, tilt-rotor aircraft, and helicopters.

Conventional Airship: An airship that uses only buoyant lift to achieve flight.

E

Envelope: The external structure of an airship within which the helium or other buoyant gas is located. There are three categories of envelopes: rigid, semi-rigid and non-rigid. Rigid envelopes use an internal frame to keep their shape. Semi-rigid envelopes use a “keel” along the bottom of the envelope to distribute weight. Non-rigid envelopes have no frame and use only gas and envelope design to keep their shape.

H

Hybrid Airship: An airship that uses a combination of buoyant lift from helium, aerodynamic lift from the shape of the envelope, and variable-direction thrust (more commonly called vectored thrust) to stay aloft.

I

Intelligence, Surveillance, and Reconnaissance (ISR): Reconnaissance operations observe an area to collect information. Surveillance is the systematic observation of a particular area. Intelligence is the product of surveillance and reconnaissance once the information from those operations has been analyzed and evaluated.

S

Strategic airlift: The use of aircraft to transport materiel, weaponry, or personnel weighing 50–100 tons over long distances, e.g., between theaters of operations.

T

Tactical airlift: The use of aircraft to transport materiel, weaponry, or personnel weighing 20–30 tons within a theater of operations.

Appendix C – Abbreviations

Programs

ATB	Aerostat Test Bed
HALE-D	High-Altitude Long Endurance Demonstrator
ISIS	Integrated Sensor is Structure
JLENS	Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System
LEMV	Long Endurance Multi-Intelligence Vehicle
PGSS	Persistent Ground Surveillance System
PTDS	Persistent Threat Detection System
RAID	Rapid Aerostat Initial Deployment
REAP	Rapidly Elevated Aerostat Platforms
STMPAS	Small, Tactical, Multi-Payload Aerostat System
TARS	Tethered Aerostat Radar System

Terms

A

A2Q	Air Force ISR Innovations Division
AAE	Army Acquisition Executive
ABO	Army Budget Office
AEWE	Army Expeditionary Warrior Experiment
AFB	Air Force Base
AFRL	Air Force Research Laboratory
AFWA	Air Force Weather Agency
AGL	Above Ground Level
AMUS	Aerostat Mounted UTAMS
AQI	Acquisitions Division
AR	Army Requirements
ARGUS	Autonomous Real-time Ground Ubiquitous Surveillance Imaging System
ARL	Army Research Laboratory
AROC	Army Requirements Oversight Council
ARSTRAT	Army Forces STRATegic Command
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
ASD(R&E)	Assistant to the Secretary of Defense (Research and Engineering)

ATEC	Army Test and Evaluation Command
AV	Air Vehicle
AWSS	Airborne Weapons Surveillance System
B	
BAAV	Buoyancy Assisted Lift Air Vehicle
BCT	Battle Command Team
BLOS	Beyond Line of Sight
C	
C2	Command and Control
C3I	Command, Control, Communications and Intelligence
C4ISR	Command, Control, Communications, Computers ISR
C5ISR	Command, Control, Communications, Computers, Combat Systems, Intelligence, Surveillance, and Reconnaissance
CD/CNT	Counterdrug/Counter-Narcoterrorism
CDD	Capabilities Definition Document
CDLs	Common Data Links
CDRT	Capability Development for Rapid Transition
CENTCOM	Central Command
C-IED	Counter-Improvised Explosive Device
CLR	Capabilities and Limitations Report
COCOM	Combatant Command
COMMS	Communications
CONUS	Continental United States
COP	Command Observation Post
COSH	Control of Static Heaviness
CPD	Capability Production Document
D	
DARPA	Defense Advanced Research Projects Agency
DoD	DoD Department of Defense
DHS	Department of Homeland Security
DMTI	Dismount Moving Target Indicator
DT	Developmental Testing
E	
EMD	Engineering and Manufacturing Development
EO/IR	Electro-optical/Infrared
EPG	Electronic Proving Ground

EPLRS	Enhanced Position Location Reporting System
ERDC	DoD Department of Defense
EUGS	Expendable Unattended Ground Sensor

F

FAA	Federal Aviation Administration
FCR	Fire Control Radar
FCS	Fire Control System
FLIR	Forward Looking Infrared
FMV	Full Motion Video
FOA	Forward Operation Assessment
FOB	Forward Operating Base
FOC	Full Operation Capability
FSRs	Field Service Representative
FVT	Functional Verification Test
FY	Fiscal Year

G

GCS	Ground Control Systems/Station
GFE	Government Furnished Equipment
GIACO	Ground Integration and Checkout
GMTI	Ground Moving Target Indicator
GNSS	Global Near Space Services

H

HAA	High-Altitude Airship
HAF	Headquarters Air Force
HARC	High Antennas for Radio Communications
HASC	House Armed Services Committee
HASS	High Altitude Shuttle System
HAV	Hybrid Air Vehicles
HD	High Definition
HNR	Highband Networking Radio
HPE	Helium Pressurization Envelope
HTA	Heavier Than Air

I

IED	Improvised Explosive Device
IFC	Integrated Fire Control

IFF	Identification Friend or Foe
IPT	Integrated Product Team
ISR	Intelligence, Surveillance, and Reconnaissance
ITS	Integrated Tactical Systems
J	
JCTD	Joint Capability Technology Demonstration
JIEDDO	Joint Improvised Explosive Device Defeat Organization
JMUA	Joint Military Utility Assessment
JROC	Joint Requirements Oversight Council
JUONS	Joint Urgent Operational Needs Statement
L	
LD/LRF	Laser Designator/Laser Range Finder
LM	Lockheed Martin
LOS	Line of Sight
LTA	Lighter than air
LWIR	Long Wave Infrared
M	
MASINT	Measurement And Signature INTelligence
MaTIC	Meteorological and Target Identification Capability
MATV	MRAP-All Terrain Vehicle
MCDL	Mini-Common Data Link
M-TCDL	Mini-Tactical Common Data Link
MDA	Missile Defense Agency
MDD	Material Development Decision
MMAR	Multi-channel, Multi-band, Airborne Radio
MRAP	Mine Resistance Ambush Protected
MS	Milestone
MSL	Mean Sea Level
N	
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NDAA	National Defense Authorization Act
NFOV	Narrow Area Field of View
NIE	Network Integration Evaluation
NORAD	North American Aerospace Defense Command

NRL	Naval Research Lab
NSCS	Near Space Communications Systems
NSMV	Near-Space Maneuvering Vehicle
NSWC PCD	Naval Surface Warfare Center Panama City Division

O

OCO	Overseas Contingency Operation
OCU	Operator Control Unit
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ONS	Operational Needs Statement
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OSRVT	One System Remote Video Terminal
OTA	Other Transaction Authority

P

PAC-3	Patriot Advanced Capabilities-3
PED	Processing, Exploitation, and Dissemination
PEO IEW&S	Program Executive Office Intelligence Electronic Warfare & Sensors
PM	Program Manager
POR	Program of Record
PRV	Payload Return Vehicle
PSDS2	Persistent Surveillance & Dissemination System of Systems
PSS-T	Persistent Surveillance System-Tethered

Q

QRC	Quick Reaction Capability

R

RAVB	Rigid Aeroshell, Variable Buoyancy
RDT&E	Research, Development, Testing & Evaluation
REF	Rapid Equipping Force
RF	Radio Frequency
RRTO	Rapid Reaction Technology Office

S

SAF	Secretary of the Air Force
SAR	Synthetic Aperture Radar
SASS	Small Aerostat/Airship Surveillance System

SIGINT	Signal Intelligence
SINCGARS	Single Channel Ground and Airborne Radio System
SIPRNet	Secret Internet Protocol Router Network
SMDBL	Space and Missile Defense Battle Lab
SMDC	United States Army Space and Missile Defense Command
SRV	Stratospheric Return Vehicle
SuR	Surveillance Radar
SuS	Surveillance System
SWIR	Short Wave Infrared
SwRI	Southwest Research Institute

T

TBLS	Tactical Balloon Launch System
TCDL	Tactical Common Data Link
TCOM	Tethered Communications (Inc.)
TOE	Table of Organizational Equipment
TRADOC	Training and Doctrine Command
TRL	Technology Readiness Level
TTNT	Tactical Targeting Network Technology
TYAD	Tobyhanna Army Depot

U

UA	Unmanned Aircraft
UAS	Unmanned Airborne System
UAV	Unmanned Aerial Vehicle
UFR	Unfunded Request
USAF	United States Air Force
USNORTHCOM	United States Northern Command
USSOUTHCOM	United States Southern Command
USD(AT&L)	Under Secretary of Defense (Acquisitions, Technology, and Logistics)
USFOR-A	United States Forces Afghanistan
UTAMS	Unattended Transient Acoustic MASINT Sensor
UTTR	Utah Test Training Range

V

VCSA	Vice Chief of Staff of the Army
VTOL	Vertical Takeoff and Landing

W

WAS	Wide Area Sensor
WFOV	Wide Area Field of View
WSMR	White Sands Missile Range

Y

YPG	Yuma Proving Ground

Appendix D – References

1. The Senate Report accompanying S.1253 (S.Rept.112-26) of the National Defense Authorization Act for Fiscal Year 2012.
2. Briefing – “DoD Lighter-Than-Air and Hybrid Aircraft Programs”, June 23, 2009. Overview for SAC-D Staff by USAF representatives.
3. “Balloons and Airships”. Florida International University webpage. Updated November 2, 2009. http://www.allstar. fiu.edu/aero/balloon5.htm.
4. Recent Development Efforts for Military Airships. Congress of the United States Congressional Budget Office. Washington D.C: CBO, 2011.
5. Airships and Balloons in the World War II Period. Judy Rumerman. US Centennial of Flight Commission. http://www.centennialofflight.gov/essay/Lighter_than_air/ Airships_in_WWII/LTA10.htm.
6. Bolkcom, Christopher—Specialist in National Defense Foreign Affairs, Defense, and Trade Division. Potential Military Use of Airships and Aerostats CRS Report for Congress.
7. Tethered Aerostat Radar System, U.S. Air Force Fact Sheet. Obtained from http://www.af.mil/information/factsheets/factsheet.asp?fsID=3507
8. “Iraqi Conflict Brings Increased Interest in Military Airships.” Navy League of the United States. July 2003. Available at http://www.navyleague.org/sea_power/jul_03_01.php
9. Directory of U.S. Military Rockets and Missiles, Appendix 4: Undesignated Vehicles. Last updated September 13, 2005. Available online at http://www.designation-systems.net/dusrm/app4/aerostats.html
10. Image provided by PTDS PM Office.
11. Report to Congress—Aerostats and Hybrid Airship Review. Office of the Under Secretary of Defense for Acquisition, Technology, & Logistics. March 1, 2011.
12. Briefing for Headquarters U.S. Air Force. “USAF Airship S&T” by representative of SAF/AQR (Science, Technology, and Engineering) 29-Jul-2010.
13. Briefing for Assistant Secretary of Defense for Research and Engineering, “Hybrid Airships.” July 19, 2011.
14. Information provided through interview with representative from Persistent Surveillance, DA G-2 Intelligence Futures Directorate.
15. Image provided by SMDBL ATB Office.
16. “High-Altitude Test Bed (HATB) Support to the Network Integration Evaluation” Information Paper prepared by Army SMDC-FWB. May 18, 2011.
17. Information provided through interview with representative from Army SMDC.
18. Images provided by manufacturer, Silicis Technologies, Inc. Information provided through interview with representative from Army REF.

19. Information provided through interview with representative from Founder of Silicis Technologies, Inc.

20. Image provided by JLENS PM office

21. Information provided through interview with representative from Army ASA(ALT)

22. Image provided by NAVAIR system command site

23. Information provided through interviews with representatives from OSD ATL and the Persistent Surveillance, DA G-2 Intelligence Futures Directorate.

24. Image provided by Persistent Surveillance, DA G-2 Intelligence Futures Directorate.

25. Image retrieved from manufacturer website. Lockheed Martin, http://www.lockheedmartin.com/us/products/lighter-than-air-vehicles/ ptds.html

26. Information provided through interview with PTDS PM Office.

27. Image provided by RAID PM office.

28. Information provided through interview with representative from Army PM ITS.

29. Information provided through interviews with representatives from ISL Inc., Army REF and Persistent Surveillance, DA G-2 Intelligence Futures Directorate.

30. Image obtained from manufacturer's factsheet. ISL Inc. Available at www.islinc.com/aeronautical_systems.php

31. Image provided by contractor GTRI.

32. Image provided by TARS PM office.

33. Information provided by interview with representative from USAF AF/A3O-AH (Operations Division, Homeland Operations).

34. Briefing—Blue Devil Block 2. Aeronautical Systems Center. Blue Devil 2 PM 645 AE56-Big Safari Program Office, USAF.

35. Information provided through interview with representative from Blue Devil 2 office, Big Safari, USAF.

36. Image retrieved from manufacturer website. Lockheed Martin, http://www.lockheedmartin.com

37. "Lockheed Martin HALE-D/HAA. IHS Global Ltd, 2011. Jane's Unmanned Aerial Vehicles and Targets. September 7, 2011.

38. Briefing—"The High-Altitude Efforts at the U.S. Army Space and Missile Defense Technology Center". U.S. Army SMDC/ARSTRAT.

39. Perry, Williams D. "Sentinel in the Sky". Technology Today, Fall/Winter 2010.

40. Information provided through interview with representative from Army SMDC.

41. Briefing—Integrated Sensor Is Structure (ISIS). DARPA Program Manager, January 10, 2012.

42. Information provided through interview with a representative from DARPA.

43. “Lockheed Martin ISIS”. HIS Global Limited, 2011. Jane’s Unmanned Aerial Vehicles and Targets. December 13, 2011.

44. Information provided through interview with a representative from the Advanced Programs Branch, USAF AFRL/RY.

45. Image obtained from manufacturer’s website. Northrop Grumman, http://www.northropgrumman.com/products/lemv.

46. Image obtained from Northrop Grumman LEMV specification sheet, “Don’t Blink”.

47. Information provided through questionnaire completed by representatives from the LEMV program office, Army SMDC.

48. “Navy’s Modern Airship Receives Historical Identification”. NRL News Release, October 27, 2011. http://www.nrl. navy.mil/media/news-releases/2011/navys-modern-airship-receives-historical-identification

49. Information provided through interview with a representative from NAVAIR.

50. “Navy MZ-3A Airship Status”, Airship Systems Engineering Team Briefing, January 2012.

51. Briefing—Project Pelican Update. March 7, 2012. RRTO and NASA Ames Research Center.

52. Image obtained from manufacturer’s website. Aeros Corporation, http://www.aeroscraft .com

53. Briefing—Project Pelican, 15 December 2011 Update. Prepared for ASD(R&E).

54. Briefing—U.S. Army Skybus 80K UAS, Army G-2.

55. Naval Research Advisory Committee Report: Lighter Than Air. April 2006. Office of the Assistant Secretary of the Navy (Research, Development and Acquisition).

56. Knoedler, Andrew J., Major USAF. “Lowering the High Ground: Using Near-Space Vehicles for Persistent ISR.” Center for Strategy and Technology, Air War College, Air University. Nov 2005.

57. Lachenmeier, Tim. “High Altitude Shuttle System Payload User’s Guide Rev A, October 14th, 2011.” Near Space Corporation

58. Briefing— Star Light Introduction. Near Space Systems, January 2012.

59. NASA’s Columbia Scientific Balloon Facility. Balloon information page available at http://www.csbf.nasa.gov/balloons.html.

60. Air Force High-Altitude Balloon Program, U.S. Air Force Fact Sheet. Air Force Research Laboratory, Kirtland Air Force Base. October 2010.

61. Briefing— ATA/Aerospace and the AFRL Balloon Program.

62. Information provided through interview with representative from the AFRL Balloon Program.

63. Briefing— Balloon Telemetry and Communications from Small Balloons. Briefing for LOCANS Conference. April 27, 2006.

64. Morris, Jeff. “Air Force Backs Away from Near Space Maneuvering Vehicle”. Aviation Week. March 18 2005. http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=aerospacedaily&id=news/NSMV03185. xml&headline=Air%20Force%20Backs%20Away%20From%20Near-Space%20Maneuvering%20Vehicle

65. Image obtained from The Nav Log available at http://www.navlog.org/nsmv.html

66. Appropriations Request Form, Oregon House Delegation. Fiscal Year 2010. Project Title: High Altitude Shuttle System (HASS).

67. Website—High Altitude Shuttle System, Near Space Corporation. NASA Flight Opportunities Program. Available at https://flightopportunities.nasa.gov/platforms/balloon/high-altitude-shuttle-system.

68. Information provided by interview with representatives from GNSS (Near Space Systems Inc.) and the Star Light development team.

69. “Providing National Security on Far Fewer Dollars”, GNSS press release. Available at http://www.globalnea-rspace.com/press_release_SPSA.shtml.